National Library of Canada
Acquisitions and Bibliographic Services Branch
395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale du Canada
Direction des acquisitions et des services bibliographiques
395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file *Votre référence*

Our file *Notre référence*

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

Canada

THE UNIVERSITY OF ALBERTA

INTERRATER RELIABILITY AND DISCRIMINANT ABILITY OF CLINICAL MEASUREMENT OF PATELLAR MOBILITY

by

LAUREN ALISON BEAUPRE

©

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF PHYSICAL THERAPY

EDMONTON, ALBERTA

FALL 1992

National Library of Canada
Bibliothèque nationale du Canada

Canadian Theses Service
Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-77295-6

Canada

RELEASE FORM

NAME OF AUTHOR: LAUREN ALISON BEAUPRE

TITLE OF THESIS: INTERRATER RELIABILITY AND DISCRIMINANT ABILITY OF CLINICAL MEASUREMENT OF PATELLAR MOBILITY

DEGREE FOR WHICH THIS THESIS WAS PRESENTED: MASTER OF SCIENCE

YEAR THIS DEGREE GRANTED: FALL, 1992

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research only.

The author reserves other publication rights, and neither the thesis nor extensive abstracts from it may be printed or otherwise reproduced without the author's written permission.

(SIGNED) L Beaupre

PERMANENT ADDRESS:
10949-54 Avenue
Edmonton, Alberta
Canada, T6H 0V2

DATED October 8 1992

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled INTERRATER RELIABILITY AND DISCRIMINANT ABILITY OF CLINICAL MEASUREMENT OF PATELLAR MOBILITY submitted by LAUREN ALISON BEAUPRE in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

Jean Wessel

Supervisor

Sharon Warren

DATED Oct 6 1992

DEDICATION

To Darcy,

for his endless patience and encouragement,

as well as for his faith in my ability to reach my goals.

ABSTRACT

The purpose of this study was to determine the interrater reliability and discriminant ability of two clinical measurements of medial and lateral patellar mobility. The first measurement consisted of the medial and lateral patellar glide tests. The second measurement consisted of a caliper measurement of medial and lateral patellar displacement.

Two groups of 25 females between the ages of 14 and 35 years, were tested by two experienced physical therapists. The first group had subjects with normal knees while the second group consisted of females with a diagnosis of patellofemoral pain. The two examiners tested each subject independently and were also blinded to the subject's grouping.

Interrater reliability of the patellar glide tests was analysed with Cohen's Kappa test while group differences of both patellar glide tests was analysed with Yate's Corrected Chi Square test. The patellar glide tests were analysed separately as well as with their results combined to form one patellar glide test. Although the reliability was adequate, neither the separate tests nor the combined test were able to discriminate between the two groups of subjects at a 0.05 level of significance for either of the examiners.

Test-retest reliability of the caliper measurement was examined through a pilot study using 10 females with normal knees. The results of the pilot study were analysed with an Intraclass Correlation Coefficient and were found to be 0.83 and 0.94 for the medial and lateral patellar displacement measurement.respectively. Interrater reliability of the caliper measurement of patellar displacement was also analysed with an Intraclass Coefficient. The coefficients were 0.35 and 0.23 for medial and lateral patellar displacement respectively. Group differences for the caliper measurement of patellar

displacement in each direction were analysed with a paired Student's t-test at a 0.05 level of significance. Neither examiner was able to discriminate between the two groups of subjects with either test.

The final objective of determining which method was superior was not examined because neither measurement showed the ability to discriminate between the two groups.

In conclusion, neither the patellar glide tests nor the caliper measurement of patellar displacement was able to discriminate between subjects with patellofemoral pain and subjects with no history of knee pain.

ACKNOWLEDGEMENTS

The completion of this thesis was dependent upon the assistance of several individuals who gave their time and expertise. I would like to extend my sincere thanks to the following individuals:

To Dr. Donna Ford, my co-advisor, for her endless guidance, support and assistance.

To Dr. Jean Wessel, my co-advisor, for her statistical assistance and constructive criticism, as well as her help in making my advisor transition trouble free.

To Dr. Sharon Warren, my committee member, for her advice regarding research design and statistical analysis.

To Dr. Steven Aaron, my committee member, for giving time out out his busy schedule to offer clinical advice.

To Candis Carrothers and Michael Zemuk, my research assistants who gave countless hours to assist in the formalization and implementation of the testing procedures. These individuals were uncomplaining of the long time commitment required of them to complete data collection.

To the orthopaedic surgeons and their office staff, in particular, Dr. Peter Boucher, Dr. John Harvey, Dr. John Cinats, Dr.Paul Leung and Dr. David Reid for their assistance in finding appropriate subjects for the study.

To the physical therapists of the Edmonton area, especially Leigh Garvie, who also assisted in finding appropriate candidates for the study.

To the physical therapy students, particularly those in their first year of the program, who gave their time to help with data collection for both the pilot study and research project.

* This study was funded by the Celia Bartzen Graduate Bursary given by the Edmonton District of the Canadian Physical Therapy Association as well as by the Strathcona Physical Therapy Award given by Strathcona Physical Therapy Limited.

TABLE OF CONTENTS

Chapter **Page**

I. THE PROBLEM ---- 1

A. Statement of the Problem ---- 1

B. Objectives of the Study ---- 5

C. Research Hypotheses ---- 6

D. Operational Definitions ---- 6

E. Delimitations ---- 8

F. Limitations ---- 9

II. LITERATURE REVIEW ---- 10

A. Introduction ---- 10

B. Patellofemoral Anatomy ---- 12

C. Patellofemoral Biomechanics ---- 20

D. Assessment of the Patellofemoral Joint ---- 29

E. Summary ---- 33

III. METHODS AND PROCEDURES ---- 35

A. Sample ---- 35

B. Personnel ---- 36

C. Subject Positioning ---- 37

D. Procedure ---- 37

E. Analysis ---- 42

IV. RESULTS ----------44

A. Interrater Reliability of the Medial and Lateral Patellar Glide Tests----------44

B. Discriminant Ability of the Patellar Glide Tests----------44

C. Interrater Reliability of Caliper Measurement of Patellar Displacement ----------49

D. Discriminant Ability of Caliper Measurement of Patellar Displacement ----------51

V. DISCUSSION----------54

A. Patellar Glide Tests----------54

B. Caliper Measurement of Patellar Displacement----------60

C. Clinical Recommendations----------64

VI. SUMMARY AND CONCLUSIONS ----------66

A. Summary ----------66

B. Conclusions ----------66

***

References ----------68

APPENDIX A: BODY MASS INDEX (BMI) SCALE ----------75

APPENDIX B: INFORMATION SHEET----------77

APPENDIX C: INFORMED CONSENT FORM ----------79

APPENDIX D: ACTIVITY LEVEL SCALE----------81

APPENDIX E: LETTER TO PHYSICIANS AND THERAPISTS----------83

APPENDIX F: KAPPA SCORE CALCULATION ----------85

APPENDIX G: RAW DATA----------87

LIST OF TABLES

Table	Description	Page
4.1	Ratings for the Medial Patellar Glide Test for Examiner One	45
4.2	Ratings for the Medial Patellar Glide Test for Examiner Two	46
4.3	Results of Yate's Corrected Chi Square Test for the Medial Patellar Glide Test for Examiner One	46
4.4	Ratings for Examiner Two for the Lateral Patellar Glide Test	47
4.5	Results of Yate's Corrected Chi Square Test for the Lateral Patellar Glide Test for Examiner Two	47
4.6	Ratings for Examiner Two for the Combined Patellar Glide Tests	48
4.7	Results of Yate's Corrected Chi Square Test for the Combined Patellar Glide Test for Examiner Two	48

Table	Description	Page
4.8	Means, Standard Deviations and Intraclass Correlation Coefficients for the Caliper Measurement of Medial Patellar Displacement	49
4.9	Means, Standard Deviations and Intraclass Correlation Coefficients for the Caliper Measurement of Lateral Patellar Displacement	50
4.10	Descriptive Statistics and Paired T-test Analysis of Examiner One and Two of Measurement of Medial Patellar Displacement by Caliper	52
4.11	Descriptive Statistics and Paired T-test Analysis of Examiner One and Two of Measurement of Lateral Patellar Displacement by Caliper	53

LIST OF FIGURES

Figure	Description	Page
2.1	Orientation of Vastus Medialis Oblique Fibres Inserting into the Patella	14
2.2	Schematic of Superficial Oblique Retinaculum (Lateral View)	18
2.3	Schematic of Deep Transverse Retinaculum (Lateral View)	19
2.4	Measurement of the Q-Angle	22

LIST OF PLATES

Plate	Description	Page
3.1	Performance of Medial Patellar Glide Test	39
3.2	Mitutuoyo Digital Caliper	41
3.3	Performance of Medial Patellar Displacement Measured by Caliper	41

LIST OF ABBREVIATIONS

ADL	Activities of Daily Living
ASIS	Anterior Superior Iliac Spine
BMI	Body Mass Index
cm	centimeters
CMP	Chondromalacia Patella
CT	Computerized Tomography
DTR	Deep Transverse Retinaculum
ELPS	Excessive Lateral Pressure Syndrome
ITT	Ilio-Tibial Tract
ICC	Intraclass Correlation Coefficient
MRI	Magnetic Resonance Imaging
mm	millimeters
PFJRF	Patellofemoral Joint Reaction Force
PFP	Patellofemoral Pain
PFPS	Patellofemoral Pain Syndrome
Q-angle	Quadriceps Angle
QF	Quadriceps Femoris
ROM	Range Of Motion
RF	Rectus Femoris
SOR	Superficial Oblique Retinaculum
VI	Vastus Intermedius
VL	Vastus Lateralis
VM	Vastus Medialis
VMO	Vastus Medialis Oblique

Chapter I

THE PROBLEM

A. Statement of the Problem

Patellofemoral pain syndrome (PFPS) is a common problem seen in rehabilitation medicine today. It is characterized by pain or aching in the peripatellar or retropatellar region during or after weightbearing activities, ascending or descending stairs, or after sitting for a prolonged period with the knee flexed (LeVeau & Rogers, 1980; Malek & Mangine, 1981; Insall, 1982; Wise, Fiebert & Kates, 1984).

Patellofemoral pain (PFP) is multifactorial in origin. Much effort has been made to discover causes of the pain and dysfunction and to determine appropriate treatment protocols. More recently, research has shown that a large number of patients presenting with true patellofemoral symptoms have abnormal biomechanics arising from anatomical factors either within or extraneous to the patellofemoral joint (Hungerford & Barry, 1979; Schutzer, Ramsby & Fulkerson, 1984; Kramer, 1986; McConnell, 1986; Tiberio, 1987).

In general, PFP is said to arise from medial hypermobility, lateral hypomobility or malalignment of the patella within the trochlear groove. Medial hypermobility occurs when dysplasia of the vastus medialis oblique (VMO) is present or when there are bony insufficiencies such as a shallow trochlear groove or patella alta (Insall, 1982; McConnell, 1986). Lateral hypomobility occurs when the fibres of the lateral retinaculum are excessively taut pulling the patella laterally. Malalignment of the patella can occur due to medial hypermobility or lateral hypomobility, but can also occur due to anatomical factors extraneous to the joint such as an increased quadriceps angle (Q-angle), femoral anteversion, tibial torsion or subtalar pronation or supination

(Insall, 1982; Tiberio, 1987).

The end result of medial hypermobility may be lateral patellar subluxation or frank dislocation. Lateral subluxation can vary in degree from a minor deviation from the normal patellar arc of motion, to a major lateral deviation whereby the patella nearly exits the trochlear groove (Fulkerson & Hungerford, 1990). Lateral dislocation occurs when the patella moves over top of the lateral trochlear facet and is no longer in contact with the groove. Laxity of the medial patellar support system is thought to be a major causative factor of PFP (Paulos, Rusche, Johnson & Noyes, 1980; Fisher, 1986; Fulkerson & Hungerford, 1990). Treatment approaches have involved strengthening programs for the quadriceps femoris (QF) muscle group with emphasis on the VMO portion of the QF. Surgical techniques have also been developed to tighten the lax medial retinaculum and to realign the patella within the trochlear groove (Paulos et al., 1980; Bourne, Hazel, Scott & Sim, 1988; Fulkerson & Hungerford, 1990).

More recently, interest has been focused on the lateral aspect of the patellofemoral joint as researchers became aware of patients presenting with lateral hypomobility. Fulkerson and coworkers (1980, 1982, 1985, 1989) have examined the lateral retinaculum in detail and believe it to be an important source of PFP. They suggest that when the lateral retinaculum becomes excessively taut, the patella is held in a more lateral position and prevented from moving freely in the trochlear groove. This lateral tightness causes pain due to stretching of the lateral retinacular fibres, and in severe cases, may also lead to patellar subluxation. In prolonged cases of lateral hypomobility, cartilage on the lateral facet of the patella may degenerate, a condition known as excessive lateral pressure syndrome (ELPS) (Fulkerson & Hungerford, 1990).

McConnell (1986) has devised a conservative treatment protocol based on stretching of the lateral retinaculum to allow improved patellar mobility and improve the patella's position within the trochlear groove. Surgical techniques have also been developed to release the lateral retinaculum (Merchant & Mercer, 1974; Larson, Cabaud, Slocum, James, Keenan & Hutchinson, 1978; Betz, Lonergan, Patterson, Litton, Yucha & Boal, 1982; Schonholtz, Zahn & Magee, 1987). In fact, because the lateral retinacular release surgery is simpler and has a lower morbidity than other patellofemoral surgical techniques, it has become extremely popular in the past decade. Postoperative medial subluxation of the patella and even medial patellar dislocation have been reported and are believed to be due to the lateral retinaculum being released when it is not excessively tight (Hughston & Deese, 1988; Busch & DeHaven, 1989; Kolowich, Paulos, Rosenberg & Farnsworth, 1990; Miller, Klein & Teitge, 1991).

Because PFP can originate from a number of causes, it is important for the clinician to have assessment tools which will assist in making the appropriate treatment decision for each individual. Several x-ray techniques appear to indicate when the patella is in an inappropriate position (Merchant, Mercer, Jacobsen & Cool, 1974; Aglietti, Insall & Cerulli, 1983; Carson, James, Larson, Singer & Winternitz, 1984; Schutzer et al., 1986). However, x-ray techniques require the knee joint to be placed in greater than 30 degrees of knee flexion. Often patellofemoral tracking and positional problems occur in the 0-30 degree range of knee flexion. Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI) appear to be more effective methods of imaging the patellofemoral joint in less than 30 degrees of knee flexion (Delgado-Martins, 1979; Martinez, Korobkin, Fondren, Hedlund & Golner, 1983; Kujala, Osterman Kormano, Komu & Schlenzka, 1989). These imaging

techniques, however, are not always readily available to the physician or the physical therapist. Exposure to radiation may be prevented if a simple clinical test is able to give the same information as an x-ray or more precise imaging technique.

There are presently very few physical tests which have been tested for reliability and validity, and can be used by the clinicians to determine the underlying cause of PFP (Elton, McDonough, Savinar & Jensen, 1985). Various tests have been developed, based on clinical experience, and are commonly used by clinicians to assist in determining the cause of PFP. However, these tests require further investigation to determine their usefulness.

Fairbank (1937) suggested that when the patella is passively displaced laterally by the examiner and the subject reacts by tensing their QF muscle group, that this response should be considered an indication of previous patellar instability. Although this test, known as the patellar apprehension test, has never undergone formal testing, it has withstood the "test of time" and is considered an indicator of gross medial patellar hypermobility. In more recent years, some authors have attempted to define the medial and lateral mobility of the patella through revision of the patellar apprehension test into the medial and lateral patellar glide tests (Bourne et al., 1988; Gecha & Torg, 1990; Kolowich et al., 1990). These authors suggest, that if the patella moves half or more of its greatest width in the lateral direction, medial hypermobility of the patella is present. Conversely, if the patella moves one quarter or less of its greatest width in the medial direction, lateral hypomobility is present. In order to make the decision as to what constitutes pathological motion of the patella in both the medial and lateral direction, it is necessary to know the normal limits of medial and lateral patellar motion. If the assumptions of these authors are correct, there should be a difference in medial and lateral patellar displacement

between subjects with PFP and those subjects without PFP. The test must also be reliable between examiners in order for it to be considered a clinical test rather than merely a clinical impression made by one examiner.

Further investigation is required to determine if the patellar glide test is a reliable indicator of pathological patellar movement and to determine, if in fact, patellar mobility differs in people with PFP when compared to people without PFP as measured by the patellar glide tests.

A second method of measuring medial and lateral patellar mobility has also been suggested by the principal investigator. This method involves the use of a digital caliper with measuring prongs which can be placed on either side of the patella at its widest portion. The medial and lateral displacement of the patella can then be measured in millimeters (mm) by the caliper as the patella is displaced by the examiner. With the use of this measurement technique, the medial and lateral movement of the patella of patients with PFP can be compared with that of subjects without PFP. This second measurement technique was suggested because it should give more precise measurements and eliminate the subjective aspect of the patellar glide tests.

B. Objectives of the Study

The specific objectives of this research project were:

1) to determine the interrater reliability of the medial and lateral patellar glide tests.
2) to determine whether the medial and lateral patellar glide tests can discriminate between patients with patellofemoral pathology and subjects with no history of knee pathology.
3) to determine the interrater reliability of caliper measurement of medial and lateral patellar displacement.

4) to determine whether the measurement of medial and lateral patellar displacement by calipers can discriminate between subjects with PFP and subjects without PFP.
5) to determine the level of agreement between the patellar glide tests and caliper measurement of patellar displacement.

C. Research Hypotheses

The research hypotheses were:

1) The medial and lateral patellar glide tests will be reliable between examiners.
2) The medial and lateral patellar glide tests will differentiate between subjects with patellofemoral pathology and subjects without patellofemoral pathology.
3) The caliper measurement of patellar displacement will be reliable between examiners.
4) A significant difference will exist in medial and lateral patellar displacement, as measured with calipers, between subjects with PFP and subjects without PFP.
5) The caliper measurement of patellar displacement will be superior to the patellar glide tests in it's ability to discriminate between subjects with PFP and subjects without PFP.

D. Operational Definitions

1) Patellofemoral pain - retropatellar or peripatellar pain occurring during or after weightbearing activities, ascending or descending stairs or sitting for a prolonged time with the knee flexed.
2) Normal knees - knees which have not required past or present

medical intervention. Subjects with normal knees will be assigned to Group One.

3) Skeletal maturity - 16 years of age or at least two years beyond menarche.

4) Patellar glide test - a clinical measurement of medial and lateral mobility of the patella performed by dividing the patella into quadrants at its widest portion. The displacement of the patella is then measured as the physical therapist applies manual resistance in either a medial or a lateral direction with the knee flexed and supported in 20-25 degrees of knee flexion.
   i) positive medial glide test - a medial glide of one or fewer quadrants will be considered positive and thus, indicative of lateral hypomobility.
   ii) positive lateral glide test - a lateral glide of two or more quadrants will be considered positive and thus, indicative of medial hypermobility.

5) Blinded - examining physical therapists are unaware of the subject's identity, history or assigned grouping

6) Physical therapist - a person who has graduated from an acknowledged school of physical therapy and is eligible for registration in the College of Physical Therapists of Alberta.

7) Swipe test - a clinical test performed to ascertain if a minimal amount of swelling is present in the knee joint cavity. To perform the test, the examiner pushes all synovial fluid towards the lateral aspect of the joint. The fluid is then displaced back towards the medial aspect of the joint. The test is designated positive when a visible amount of fluid accumulates on the medial aspect of the joint.

8) Apprehension test - a clinical test performed to determine medial instability of the patella. The knee is placed in 15-30 degrees of knee flexion and the patella is displaced laterally by the examiner. If the patient contracts her quadriceps or attempts to stop the examiner from continuing the test, the result is positive and indicates that there has been a previous patellar dislocation or significant patellar subluxation.

9) Giving way of the knee - sudden flexion of the knee as the subject attempts to weightbear on her leg. The subject may or may not lose her balance as a result of the momentary loss of support.

E. Delimitations

The investigation was delimited as follows:

1) To female subjects:
   a) between the ages of 14 and 35 years of age with a body mass index (BMI) of between 18 and 27.
   b) with a diagnosis of PFP from either an orthopaedic surgeon, a family physician or a licensed physical therapist.
   c) with PFP present for a minimum of two weeks and a maximum of eight years.
   d) with no previous major patellar subluxation or patellar dislocation.
2) To measurement of manual medial and lateral patellar glide tests as performed by two therapists.
3) To measurement of medial and lateral patellar glide distance with a set of calipers.

F. Limitations

Limitations of the tests examined included the examiner's judgement in deciding when the maximum tissue resistance had been reached.

A second limitation was the ability of the examiners to choose the widest portion of the patella to divide the patella into quadrants and to set the calipers into position for measurement of patellar displacement.

The third limitation was the ability of the examiners to position the subject's limb. The knee was to be placed into 20-25 degrees of knee flexion and the lower extremity maintained in neutral rotation. Positioning was done independently by each of the examiners.

Chapter II

LITERATURE REVIEW

A. Introduction

PFPS remains a challenge for the clinical therapist and orthopaedic surgeon to assess completely and therefore, to treat adequately. Initially it was believed that PFP was synonymous with chondromalacia patella (CMP) which can be defined as visible softening and/or eroding of the hyaline cartilage that covers the undersurface of the patella. With the advent of arthroscopic surgery, however, it was shown that a large number of patients presenting with patellofemoral symptoms had no visible changes in the cartilage. Conversely, patients could have degenerative changes present in the patellofemoral joint with no history of symptoms (Leslie & Bentley, 1978; Lund & Nilsson, 1980). These discoveries led to an acceptance of two pathological states; that of CMP and that of PFPS. CMP is now only diagnosed through surgery with the finding of visible degenerative changes in the patellar hyaline cartilage. PFPS encompasses all pain syndromes eminating from the patellofemoral joint, including CMP (Malek & Mangine, 1981; Callaghan & Baltzopoulas, 1992).

The realization that not all patients had distinct cartilaginous changes in their patellofemoral joint led to further research to try and identify the sources of pain for PFPS. With CMP, the primary source of pain was believed to be subchondral bone underlying the hyaline cartilage. Hyaline cartilage is aneural and is designed to cope with high compressive loads with high friction components. There is, however, a finite limit to this capability. Healthy hyaline cartilage permits sufficient deformation under load to spread the force over a large area so that the pain threshold of the underlying, highly innervated subchondral bone is not surpassed (Hungerford & Barry, 1979). When

pressures become too high due to a variety of reasons, cartilage will soften, and more force will be felt at the subchondral level, resulting in pain. Conversely, cartilage softening can also occur due to absence of adequate loading, interrupting the mechanism of cartilage nutrition, with the same end result (Hungerford & Barry, 1979).

The same mechanism of pain may be present in PFPS even though the degenerative changes in the hyaline cartilage have not reached the point that they are visible to the naked eye. Goodfellow, Hungerford and Woods (1976) examined the cartilage histologically and found that fibrillation of collagen in the middle and deep layers of the cartilage could be present without affecting the surface layer. They defined these changes as basal degeneration. The outcome of basal degeneration is softening of the cartilage, altering its ability to withstand compressive loading, and resulting again in the surpassing of the pain threshold of the underlying subchondral layer. Basal degeneration also appears to release byproducts into the synovial lining and may lead to synovial irritation. The consequence of this irritation is not only synovial effusion, but also pain because the synovial tissue is highly innervated (Grana & Kriegshauser, 1985).

Most of the research done in the past twenty years has examined the anatomy and the biomechanics of the patellofemoral joint to try and determine reasons for the development of PFPS. It has been shown that the patellofemoral joint is well designed to cope with the high loads which are passed through it during activities of daily living (ADL) when it is positioned correctly within the trochlear groove (Hungerford and Barry, 1979). When the alignment of the joint surfaces is altered, however, there may be areas of overloading and also areas of underloading of the hyaline cartilage. The change in joint surface alignment can occur due to anatomical anomalies or

alterations within the joint or its supporting structures. Alignment of the entire lower extremity may also affect the alignment of the patellofemoral joint (Hungerford & Barry, 1979; Fulkerson, 1982; Schutzer et al., 1984; Kramer, 1986; McConnell, 1986; Tiberio, 1987).

B. Patellofemoral Anatomy

Originally a sesamoid bone found within the QF muscle's tendinous insertions, the patella has now evolved along with the trochlear groove into a "true" joint which has its own capsular and synovial lining and fibrous supporting structures (Paulos et al., 1980). The superior portion of the undersurface of the patella is covered with hyaline cartilage which reaches up to five mm thick in the central portion, making it the thickest cartilage in the body (Fulkerson & Hungerford, 1990). The patellar articular surface can be divided by a vertical ridge into medial and lateral facets which correspond to the articular surfaces of the trochlear groove. The articular surface can also be divided into three transverse sections, the inferior, middle and superior. They come into contact with the trochlear surface in that order, as the knee flexes.

The trochlear groove of the femur can also be divided into medial and lateral facets which are in congruence with the contours of the patellar facets. The femoral surface begins as a shallow groove proximally and becomes deeper as it moves distally to become the intercondylar notch. The lateral facet of the trochlear groove is larger and extends further proximally than the medial trochlear facet. The lateral trochlear facet also has thicker articular cartilage than the medial trochlear facet, varying from two to three mm thick at its densest portion (Fulkerson & Hungerford, 1990).

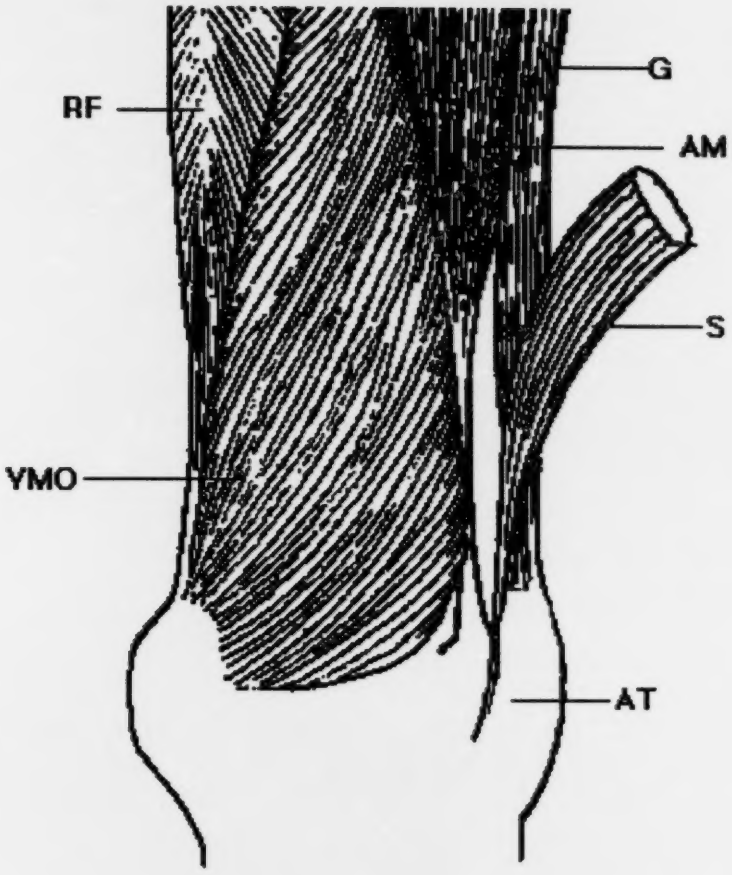
The patellofemoral joint is an unusual joint in that its stability is provided primarily by a dynamic stabilizer on its medial aspect and by static stabilizers on

its lateral aspect. Dynamic stability is provided by the VMO, a portion of the QF muscle. The lateral retinaculum, which is a fibrous structure, provides the primary lateral stability.

VMO has been the centre of much controversy in the rehabilitation domain. It was initially believed that the vastus medialis (VM) muscle was responsible for the final 30 degrees of knee extension (Fox, 1975; Francis & Scott, 1974). This was believed because when patients developed a QF lag of approximately 30 degrees post trauma or post-operatively, there was marked wasting of the VM while the rest of the QF group appeared to have normal bulk. Lieb and Perry (1968), however, demonstrated that a 60% greater force was required by all the components of the QF muscle to straighten the knee from 30 degrees flexion to zero degrees extension than was required to extend the knee from 90 degrees to 30 degrees flexion in a non weightbearing position. These authors suggested that it was general QF weakness, rather than a specific weakness of VM, that prevented terminal knee extension.

By far the most important anatomical revelation of Lieb and Perry was the distinction between the VM and the VMO. At the distal one third of the VM muscle, the fibre orientation changed from approximately 18 degrees from the axis of the femoral shaft, to 50 to 55 degrees (See Figure 2.1). This portion of the QF muscle, with the more horizontal fibre orientation, was given the name VMO by these authors. Later studies have supported their findings and in fact, have shown that there may be even a sharper change in fibre orientation, up to 70 degrees from the femoral shaft (Bose, Kanagasuntheram & Osman, 1980). The difference in orientation and function of the fibres from VM and VMO, convinced Lieb and Perry that these two parts of QF should be considered as separate muscles.

Thiranagama (1990) provided further support for the distinction between



ABBREVIATIONS: RF - Rectus Femoris G - gracilus; AM - Adductor Magnus; S - sartorius; VMO - Vastus Medialis Oblique; AT - Adductor Tubercle.

FIGURE 2.1 Orientation of Vastus Medialis Oblique Fibres Inserting into Patella. (Adapted from Bose K, Kanagasuntheram R & Osman MBH: Vastus Medialis: An Anatomic and Physiologic Study. Orthopaedics 3: 880, 1980)

VM and VMO. She performed a detailed study of the nerve supply to the VM muscle and found that there were two distinct branches supplying the muscle in all of the 30 specimens examined. A lateral branch originating from the spinal nerve roots of L3 and L4 supplied the upper one third of the muscle. A thicker medial branch supplied the lower two thirds of the muscle with the lowermost portion being the most richly innervated. The origin of these nerve fibres appeared to be from L1, 2 and L3 spinal nerve roots. She found that the lateral branch of the nerve supplying the upper third of VM received the same spinal input that vastus intermedius (VI) did, and so speculated that the function of the upper portion of the VM was closely aligned to the function of the VI muscle. The lowermost portion of the VM muscle, based on its nerve supply and distinct morphological differences, appeared to be functionally separate from the upper one third of the muscle.

The VMO also inserts more distally than does the vastus lateralis (VL). In normal subjects, the VMO appears to be attached to one third to one half of the medial border of the patella (Bose et al., 1980). The VL muscle fibres end more proximally, becoming tendinous an average of 2.8 centimetres (cm) above the superior border of the patella. The tendinous fibres also do not extend down the lateral border of the patella. The average angle of the VL muscle fibres changes from approximately 18 degrees to only 31 degrees from the axis of the femoral shaft at the point of attachment to the QF muscle tendon (Hallisey, Doherty, Bennett & Fulkerson, 1987). Its medial fibres insert directly into the upper lateral margins of the patella, while the lateral fibres pass to aid in the strengthening of the lateral retinaculum (Reider, Marshall, Koslin, Ring & Girgis, 1981). Therefore, minimal lateral dynamic stabilization of the patella is offered by the VL portion of the QF muscle.

Lieb and Perry (1968) tried to discover how each component of the QF

muscle contributed to extending the knee by using wires inserted into each QF component along the axis of the muscle fibre. They then pulled on the wires to get a force measurement of the load required to straighten the knee as well as to see how each QF component contributed to knee extension. With a concentric knee extension load, it was found that VM was responsible for simple extension of the knee, while the primary function of the VMO was medial stabilization of the patella. When VL was loaded independently of all other QF components, there was marked lateral subluxation of the patella. When VL and VMO were loaded simultaneously, less total force was required to extend the knee to zero degrees extension, and the patella remained centered in the groove. The VMO could not independently extend the knee to full extension. In fact, the femur fractured before reaching full extension on each of the attempts.

Primary static stabilizers of the lateral aspect of the joint include the iliotibial tract (ITT), the lateral retinaculum, and the lateral femoral condyle (Terry, Hughston & Norwood, 1986; Fulkerson & Hungerford, 1990). The lateral femoral condyle projects further anteriorly than the medial femoral condyle and acts as a buttress to the patella preventing lateral patellar subluxation and dislocation. The ITT offers support through it's action as the origin for part of the lateral retinaculum. At the level of the VL portion of the QF tendon, the ITT also sends off fibres proximally that interdigitate with the tendinous insertion of the VL muscle (Hallisey et al., 1987).

The lateral retinaculum can be divided into at least two distinct layers, the superficial oblique retinaculum (SOR) and the deep transverse retinaculum (DTR), also known as the iliopatellar band (Fulkerson & Gossling, 1980; Terry et al., 1986). Terry et al.(1986) performed a more detailed dissection in which they divided the retinaculum into four layers by looking at the orientation of the fibres. They felt that this variation in fibre orientation served to strengthen the

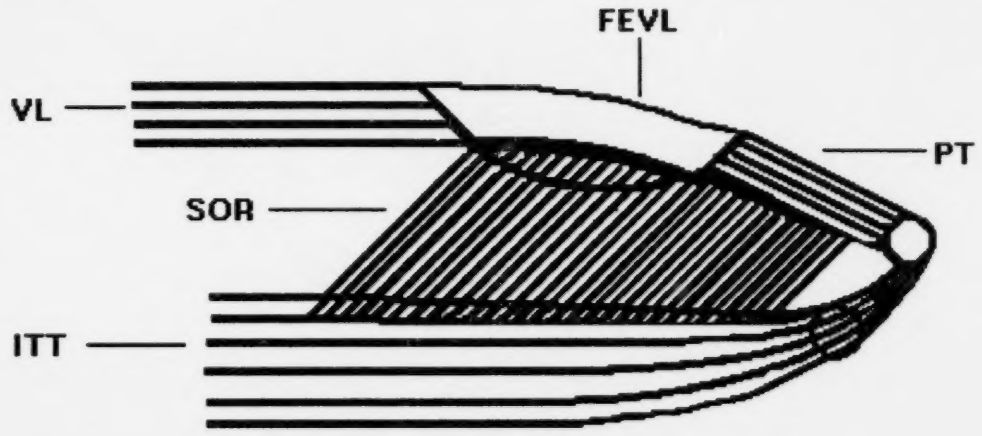
retinaculum.

The SOR originates from the ITT at the level of the knee and is thickest at its proximal end. Fibres pass down and medially to interlock with fibres of the VL and its tendinous insertion. Most SOR fibres are inserted into the anterior aspect of the patellar tendon, although a few fibres were found to have passed deeper to insert onto the posterior aspect of the patellar tendon (Fulkerson & Gossling, 1980) (See Figure 2.2).

The DTR or iliopatellar band is found underneath the SOR at its superior end. It arises from the fascia lata and passes transversely to insert directly into the lateral patella. At the level of the patellar tendon, the DTR is no longer present (Fulkerson & Gossling, 1980) (See Figure 2.3).

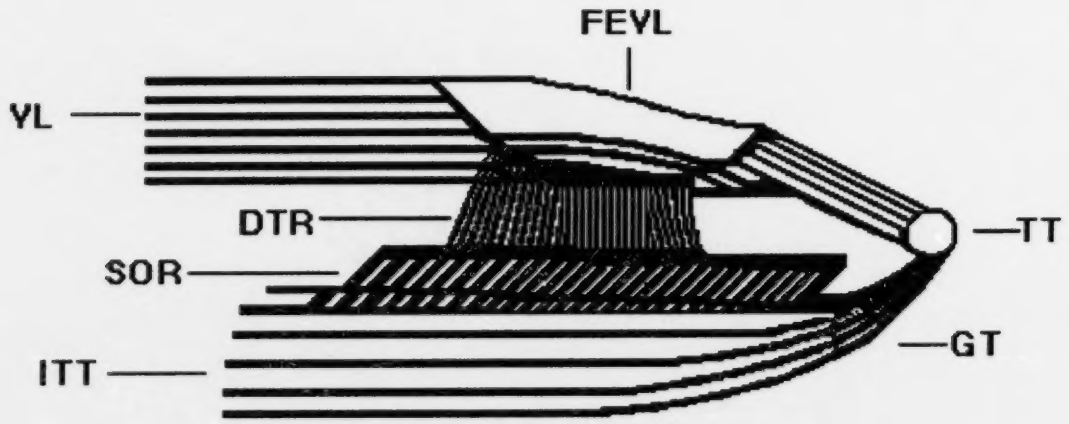
On the medial side of the joint, a retinaculum can also be found, but it is just a thickening of the fascia overlying the VMO muscle. It is given some additional strength by the oblique fibres of the superficial medial collateral ligament which passes superiorly from the anteromedial aspect of the tibia to blend with the fascia of the VMO (Warren & Marshall, 1979).

Fulkerson (1982) has looked in depth at the lateral retinaculum to discover its role in eliciting pain in PFPS. He found that in the early stages of dysfunction, when no apparent cartilage changes had occurred, that the retinaculum could be tender to palpation and that pain could be nullified by injecting the painful area with lidocaine. In a later study (Fulkerson, Tennant, Jaivin, & Grunnet, 1985), which examined the lateral retinaculum histologically, he and colleagues found increased perineural fibrosis and a mild to moderate loss of myelinated fibres In addition, patients with more severe dysfunction and pain, had even greater fibrosis and loss of myelinated fibres (Fulkerson et al., 1985). Thus, it appears that a third source of pain in PFPS may be the lateral retinaculum.



ABBREVIATIONS: SOR - Superficial Oblique Retinaculum; VL - Vastus Lateralis; ITT - Iliotibial Tract; FEVL- -Fibrous Expansion of Vastus Lateralis; PT - Patellar Tendon

FIGURE 2.2 Schematic of the Superficial Oblique Retinaculum (Lateral View). (Adapted from Fulkerson JP & Gossling HR: Anatomy of the Knee Joint Lateral Retinaculum. Clin Orthop 153: 184, 1980)



ABBREVIATIONS: VL - Vastus Lateralis; FEVL- -Fibrous Expansion of Vastus Lateralis; ITT - Iliotibial Tract; DTR - Deep Transverse Retinaculum; SOR - Superficial Oblique Retinaculum; TT - Tibial Tuberosity; GT - Gerdy's Tubercle.

FIGURE 2.3 Schematic of the Deep Transverse Retinaculum (Lateral View). (Adapted from Fulkerson JP & Gossling HR: Anatomy of the Knee Joint Lateral Retinaculum. Clin Orthop 153: 184, 1980)

Having identified the intricate nature of the supporting network of the patellofemoral joint, it becomes easier to understand how changes in the support of the patellofemoral joint surfaces will alter joint alignment and lead to PFP.

C. Patellofemoral Biomechanics

1. Normal Biomechanics

Studying the biomechanics of the patellofemoral joint has been an area of interest for many researchers in the past two decades. Researchers and clinicians have become aware that a majority of patients complaining of patellofemoral pain appear to have differences in lower extremity alignment or joint surface alignment.as compared to subjects with no complaints of PFP.

The primary function of the patella is to facilitate knee extension by increasing the distance of the extensor mechanism from the axis of flexion and extension, thereby effectively increasing the length of the moment arm of the QF muscle (Paulos et al., 1980). Initially, the patella was thought to serve as a frictionless pulley within the quadriceps expansion, but further research has shown that it acts as a lever arm, enabling the QF muscle to increase its extension force by as much as 30% through knee ROM (Malek & Mangine, 1981). This function requires that large compressive forces be passed through the patella during both static and dynamic QF contractions. Obviously then, the position in which the patella is situated and the path that it follows as the knee flexes is very important to maintain a painfree joint.

With the knee in full extension, the femur and tibia form a valgus angle known as the Q-angle. This angle is formed by a line drawn distally from the anterior superior iliac spine (ASIS) through the femoral shaft, to the center of the patella. This line intersects with another line drawn superiorly from the tibial

tubercle through the patellar tendon, to the center of the patella. The Q-angle is less than 20 degrees in the normal knee (Rusche & Mangine, 1988) (See Figure 2.4).

As the knee moves from full extension to full knee flexion, the patella follows a set pattern of motion dependent on the individual's anatomical structure. Normal patellar motion through knee flexion and extension follows a path of a "C" open laterally (Hungerford & Barry, 1979; Reider, Marshall & Ring, 1981). With commencement of knee flexion, the tibia derotates, decreasing the lateral vector and therefore, the Q-angle, but the patella still enters the joint from a slightly lateral position. At 20 to 30 degrees of knee flexion, the patella is most prominent due to the prominence of the trochlear groove (Fulkerson & Hungerford, 1990).

At flexion greater than 30 degrees, the patella is in a more medial position as it settles into the trochlear groove where it remains until 90 degrees of flexion is reached. After this point, the movement is lateral again, as the patella moves over the femoral condyle of the femur. At 135 degrees flexion, or full range of motion (ROM) of knee flexion, the patella is completely covering the lateral femoral condyle (Grana & Kriegshauser, 1985).

While the patella is moving through this arc, its articular surface is changing its pattern of contact with the femoral surface of the joint. This acts as a protective function for the cartilage of the articular surface by dispersing increased joint pressures over a larger contact area (Hungerford & Lennox, 1983; Huberti & Hayes, 1984).

In full extension, the patella does not sit in the trochlear groove, but instead sits above it, articulating with the fatpad of the supratrochlear fossa. There is some controversy as to whether the patella is centered at that time or is sitting in a slightly lateral position. Martinez et al. (1983) found that their 20

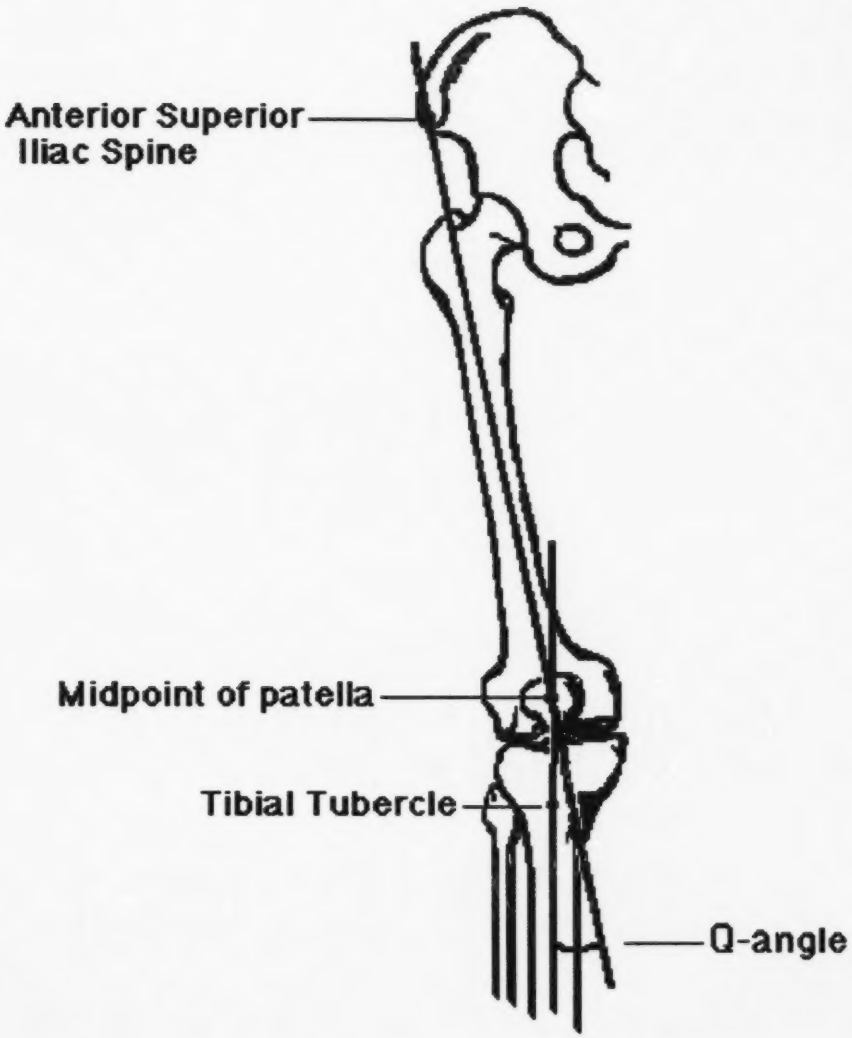


FIGURE 2.4 Measurement of the Q-Angle.

(Adapted from Bourne MH, Hazel WA, Scott SG & Sim FH: Anterior Knee Pain. Mayo Clin Proc 63: 486, 1988)

normal subjects had centered patellas in full extension whether or not the QF was contracting, while Delgado-Martins (1979) stated that his 12 normal subjects had laterally placed patellas in full extension with the quadriceps muscle relaxed. Schutzer et al. (1986) stated that a small degree of lateralization of the patella was acceptable at zero and five degrees flexion, but that the patella should be centered by 10 degrees. Initial contact with the trochlear groove is made at 10 to 20 degrees of flexion. The degree of flexion required is dependent on the length of the patellar tendon (Fulkerson & Hungerford, 1990). As its length is increased, it will take increased knee flexion for the patella to enter the groove.

The initial site of contact on the articular surface of the patella is along its inferior margin in a narrow band which extends across both the medial and lateral facets (Hungerford & Barry, 1979). As flexion is increased, the band of contact moves proximally and also increases so that by 80 to 90 degrees of flexion, all of the articular surface of the patella, with the exception of the odd facet, has come into loadbearing contact with the trochlear surface. This contact is spread equally between the medial and lateral facets.

After 90 degrees, the lateral facet of the patella begins to move onto the condylar facets of the femur, the medial odd facet makes contact with the lateral margin of the medial femoral condyle, and the rest of the medial facet moves into the intercondylar notch. At this point, the quadriceps tendon begins to share in the loadbearing as it comes into contact with the trochlear facets of the femur (Huberti & Hayes, 1984).

At 135 degrees or full knee ROM, the lateral facet is in contact with the area of the femur which corresponds to the femoral contact area of the tibia in full extension. The medial facet is no longer involved in any loadbearing as it sits fully in the intercondylar notch, while the entire surface of the medial odd

facet is in contact with the lateral border of the medial femoral condyle (Fulkerson & Hungerford, 1990).

Changes occur not only in the contact area, but also in the pressure that is exerted across this surface as movement occurs. When the quadriceps muscle contracts, the patella experiences both a tension force and a compression force. The tension force arises from quadriceps tendon pull, while the compression force arises from the reaction of the patellar ligament to this tension force. This is known as the patellofemoral joint reaction force (PFJRF) and is formally defined as being equal and opposite to the resultant of quadriceps tension and patellar tension acting perpendicular to articular surfaces (Grana & Kriegshauser, 1985). The final determination of the force is dependent upon the QF force, which will be affected by body weight and individual anatomic variations, and the knee flexion angle (Fulkerson & Hungerford, 1990).

There have been several experiments which have examined the magnitude of the PJFR as the knee moves through flexion and extension. Because of differences in techniques of measuring, results are often different quantitatively, but not qualitatively. When in weightbearing position (physiologic loading), the PFJRF increases with increased flexion as the angle between the quadriceps tendon and the patellar tendon becomes more acute and the effective lever (resistance) arms of the femur and the tibia increase. Increased QF force is then required to resist the flexion moment of body weight (Hungerford & Barry, 1979).

The joint has been well designed to cope with this increased PFJRF because as the joint force is increasing, so is the area of contact over which to disperse the force. These increases are not linearly related to each other, so the patellar pressure is not kept constant. Thus, at angles of flexion greater than

90 degrees, the quadriceps tendon also assists in loadbearing to help disperse the increasing pressure (Hungerford & Barry, 1979). Huberti and Hayes (1984) studied cadaver knees and found that the patellofemoral contact forces were distributed evenly over the areas of the patella in contact with the femur, when the Q-angle fell within a normal range.

2. Abnormal Patellofemoral Biomechanics

Several theories have been proposed to suggest why the alignment of the patellofemoral joint surfaces will vary from the normal pattern. Some of these theories have been well-substantiated, while others have only the theoretical precepts to support them. Pathomechanics may occur due to anatomical variation extrinsic to the patellofemoral joint in the form of altered biomechanics of the hip and foot (Paulos et al., 1980; Tiberio, 1987). Intrinsic to the joint, pathomechanics can arise from two different sources. They can arise due to anatomical anomalies in the joint's bony structures or they can be due to deficiencies or alterations in the static or dynamic supporting structures (Paulos et al., 1980).

Patellofemoral alignment can be affected by variations in the lower extremity alignment such as femoral anteversion, genu valgum, internal tibial torsion, and increased pronation of the subtalar joint. These changes can lead to an increased Q-angle which increases the lateral vector of the QF muscle pull and results in lateral positioning or subluxation of the patella (Grana & Kriegshauser, 1985; Kramer, 1986; Paulos et al., 1980; Rusche & Mangine, 1988; Tiberio, 1987). Therefore, all of the extrinsic factors have a similar effect on the patellofemoral joint alignment. The only difference between the factors, is the location of the structure responsible for altering the joint biomechanics.

Patellofemoral biomechanics are also affected by bony anomalies in the joint's structure. These anomalies include a flattened trochlear groove, medial patellar facet hypoplasia, lateral femoral condyle hypoplasia and patella alta. (Kujala et al., 1989; Paulos et al, 1980; Schutzer et al., 1986). These factors, again, can lead to a laterally placed patella at rest, or lateral tracking or subluxation of the patella with a QF contraction. All of these structural anomalies with the exception of patella alta, are believed to be developmental in nature. Because of prolonged abnormal pressures and loading, these bones do not have the opportunity to develop normally. It has been noted that these anomalies can change, as bone development can occur late in the maturing skeleton (Paulos et al., 1980). For this reason, conservative measures are used whenever possible, to treat patellofemoral pain if skeletal maturity has not yet been reached.

The joint's supporting structures also influence the patellofemoral forces and joint surface alignment. Variations in static support structures include genu recurvatum and hypermobility of the medial retinacular support with concomitant hypomobility of the lateral retinaculum. Alteration of the dynamic support may be seen when there is VMO dysplasia, or traumatically induced atrophy of the QF muscle (Paulos et al., 1980; Spencer, Hayes & Alexander, 1984).

Genu recurvatum or hyperextension of the knee may lead to slackness of the extensor mechanism in full extension, which in this case, is greater than neutral extension. This laxity in the extensor mechanism is often associated with patella alta. It is suggested that more knee flexion will be required for the patella to move into the trochlear groove, so there is a greater time in which the supporting structures of the joint can affect the patella's position (Carson et al., 1984).

Hypermobility of the medial retinaculum is often associated with hypomobility of the lateral retinaculum, and Fulkerson and Hungerford (1990) suggest that a difference in tissue tension may develop on either side of the patella under these conditions. This tension difference on either side of the patella may result in tilting of the patella towards the hypomobile lateral side. Lateral patellar tilting may increase with increased knee flexion because the lateral retinaculum is attached to the ITT (Fulkerson & Gossling 1980; Fulkerson & Shea, 1990). As knee flexion is increased, the ITT is drawn more posteriorly, and the patella will be pulled laterally (Johnson, 1989). Fulkerson & Hungerford (1990) speculate that lateral hypomobility can develop when soft tissue development does not keep up with bony development during rapid skeletal growth in adolescence.

Chronic lateral tilting of the patella may have more severe consequences on the articular cartilage than subluxation alone. Tilting appears to result in prolonged and excessive lateral pressure on the lateral patellar facet with unloading of the cartilage of the medial patellar facet (Johnson, 1989). Ficat, Ficat and Bailleux (1975) were the first group to describe this specific malalignment syndrome and reported finding erosion of the lateral patellar facet and thickening of the lateral retinaculum at surgery. Since their published report, several other authors have concurred with their findings (Larson et al., 1978; Fulkerson, Schutzer, Ramsby & Bernstein, 1987; Fulkerson & Hungerford, 1990). These specific findings have, in fact, been elevated to a separate syndrome within PFPS and has been termed ELPS (Kramer, 1986; Fulkerson & Hungerford, 1990). Because articular cartilage can not withstand simultaneous and prolonged compression and shear forces, the degeneration of the cartilage can occur much faster than is seen with patellar subluxation (Fulkerson & Shea, 1990).

Dysplasia of the VMO can affect the effectiveness of the dynamic medial support system of the patella and may allow lateral subluxation or tilting of the patella. Dysplasia is the absence of VMO down the medial one third to one half of the patella. Thus, the angle of orientation of the VMO fibres is less than the 55-70 degrees measured under normal circumstances. Instead, the fibres insert on the superomedial aspect of the patella at a more vertical angle, thereby reducing the effectiveness of the muscle pull on the medial side of the patella (Paulos et al., 1980; Insall, 1982).

Trauma induced atrophy will affect all components of the QF muscle, but may affect the VM more than the QF components (Kennedy, Alexander & Hayes, 1982). When the knee is injured for any reason, it responds with an effusion resulting in neuromuscular inhibition of the QF muscle, a mechanism known as reflex inhibition. It has been found that a relatively small effusion can cause significant QF inhibition, with VM being the most severely affected component of the QF muscle (Spencer et al., 1984). Spencer et al. (1984) suggest that if the effusion is slight, and remains for a prolonged time period, that selective VM atrophy may occur. Their suggestion may be supported by Thiranagama's (1990) finding of a separate branch of the femoral nerve supplying the distal two thirds of the VM muscle. This specific atrophy may affect VMO's ability to maintain the position of the patella and lead to lateral tracking of the patella during knee flexion.

Although several sources of altered biomechanics and pain have been identified, and several theories regarding the etiology of PFPS have been suggested, the clinical picture is still not easily defined. This difficulty in determining the clinical portrait occurs because it is not necessary for the factors discussed previously to be present for PFPS to occur, or conversely, these factors can be present without the presence of PFP. As well, in the clinical

situation, the factors which can contribute to the development of PFPS rarely appear individually, but instead, can occur in any combination.

D. Assessment of the Patellofemoral Joint

Assessment of a joint is aimed at determining what structure is causing the dysfunction leading to pain so that treatment can be directed at alleviating the problem. For PFPS, it would appear that the clinician needs to be able to differentiate between whether the pain is due to weakness or dysplasia of VMO, hypomobility of the lateral retinaculum, a combination of these two factors or whether there are factors extrinsic to the joint which are leading to changes in joint surface alignment. Bony anomalies will require diagnosis through imaging techniques.

Merchant et al. (1974) were the first to suggest that there were measurable differences between some groups of PFP patients and subjects with no history of PFP on X-ray views of joint surface alignment. He and his co-workers examined alignment of the patellofemoral joint of 100 subjects with no history of knee pain and compared these findings with a group of patients with recurrent patellar dislocation. The radiographic examination was performed with the knee flexed to 45 degrees to allow a clear view of the joint surfaces. They found an increased sulcus angle and a decrease in joint congruency in the pathological group. Aglietti et al. (1983) followed this study with a similar one, and concurred with Merchant et al. (1974), that significant differences existed between the normal population and those with recurrent patellar subluxation. A third group with PFP, but without patellar instability, presented with a normal sulcus angle and a small decrease in joint congruency (Aglietti et al., 1983). Insall, Aglietti and Cerulli (1983) also did a retrospective study to determine if these changes in patellar alignment were altered by surgical

intervention. They suggested that there was a positive correlation between satisfactory postoperative results and alteration in X-ray measurements towards normal values. However, because X-rays were not done in most of their satisfactory results, they were unable to draw formal conclusions regarding the predictive value of this imaging technique. Reports have varied regarding the prognostic value of Merchant's X-ray view. Some authors (Johnson, 1989; Gecha & Torg, 1990; Kolowich et al., 1990) stated that there was no correlation between changes in postoperative X-rays and satisfactory outcomes while Dzioba (1990) found a very high correlation between satisfactory outcomes and changes in postoperative X-rays.

With the onset of the advanced imaging techniques of CT scan and MRI, the joint surface alignment of the patellofemoral joint could be viewed in the initial 30 degrees of knee ROM. Schutzer et al. (1986) identified three patterns of malalignment in a group of 22 subjects with PFP in the initial 30 degrees with the use of CT imaging. They found one group of six subjects whose patella was lateralized in the initial 30 degrees, but was centralized after that point. Another group of seven subjects had their patellas centred within the trochlear groove for the entire 30 degree range but tilted laterally during the entire range. These were joint alignment alterations which would have been missed by the standard Merchant X-ray view. It is interesting to note that within this group of 22 subjects, there were also four subjects who presented with the same clinical picture, but showed no difference in alignment from the ten normal control subjects. Fulkerson et al. (1987) did a followup study to determine the predictive value of the CT scan in determining when a lateral retinacular release was indicated. They reported that the patellar tilt tended to reduce to within normal limits post lateral retinacular release in subjects with satisfactory outcomes. These authors concluded that the CT scan was a useful tool to assist

in determining the appropriate surgical intervention. However, a control group was not used for comparison. In addition, CT scans are not necessarily routine examinations done for the patellofemoral joint. The usefulness of this tool may be precluded by its general inaccessibility.

Until recently, the only measurement tests that a physical therapist has had to use were the Clark's patellar compression test and Fairbank's patellar apprehension test. Clark's patellar compression test consists of placing the affected knee in full extension and having the patient keep the QF relaxed. The examiner then pushes the patella inferiorly and maintains that position while the patient contracts their QF muscle. The test is considered positive if pain is elicited from the retropatellar area. Gaughwin (1985) tested 400 normal school age males and females using Clark's patellar compression test. He found a positive response in 78.5% of the sample indicating that this test is not specific to CMP or PFPS. Hoke (1981) examined the literature and found nine distinct variations of the patellar compression test. The tests differed from each other primarily in the position in which the knee was tested and where the compression or resistance to the patellar motion was added. None of these other variations have been examined for their sensitivity or specificity for the diagnosis of PFPS. Based on the findings of Gaughwin (1985), these tests must also be considered suspect until they have been proven otherwise.

Fairbank's apprehension test, as mentioned previously, is the other most commonly used measurement test. It indicates gross medial patellar instability and generally confirms the history given by the patient of a previous major lateral patellar subluxation or dislocation (Bourne et al., 1988).

McConnell (1986) described a treatment of the lateral static support structures of the patellofemoral joint. Unfortunately, McConnell's procedure for the assessment of the integrity and mobility of the lateral retinaculum was not

been well described. The lack of an adequate description of her assessment and treatment makes it difficult for other clinicians to try to reproduce her findings. In order for this type of examination to become a useful part of the patellofemoral assessment, it will be necessary to know if these techniques can be performed reliably by different examiners and will differentiate between people with PFP and people without PFP.

Several physicians are also claiming that it is possible to test the mobility of the lateral retinaculum using a simple clinical test (Bourne et al., 1988; Gecha & Torg, 1990; Kolowich et al., 1990). The advantage to this test is that it is done in less than 30 degrees of knee flexion where standard imaging techniques cannot be used effectively. These authors report that if the patella can be displaced medially one or fewer quadrants of its widest portion, the lateral retinaculum is hypomobile. Gecha and Torg (1990) took several physical measures on PFP prior to surgery and related these measures to postoperative outcome. They concluded that the medial patellar glide measurement was the best predictive sign of whether or not a lateral retinacular release would be an effective surgical intervention. They found inconsistent changes in the Merchant X-ray view taken on 26 knees postoperatively and determined that this X-ray measure had no prognostic value. Kolowich et al. (1990) determined from a retrospective study of 49 knees that a patellar tilt test and the medial and lateral patellar glide tests were the most important predictors of whether or not a lateral retinacular release would be an effective treatment. They also concluded that Merchant's X-ray views did not correlate well with the clinical tests or the patient's outcome. None of these authors indicate how the measurement of one or fewer quadrants of medial patellar mobility was chosen as a marker of pathological patellar movement. Because medial patellar subluxations or dislocations can occur after lateral retinacular release, it would

appear essential that this test reliably discriminate between normal and abnormal medial patellar mobility.

Gecha and Torg (1990) and Bourne et al. (1988) also described a lateral patellar glide test used to determine when there was lateral patellar hypermobility present. Again, the boundaries of what constituted abnormal mobility appear to have been arbitrarily chosen based on clinical judgement rather than a formal comparison of normal and patellofemoral subjects.

Clark's test was used for several years in the medical community with the belief that it indicated that retropatellar pathology was present. With Gaughwin's findings in 1985, it would seem that formal testing of any new diagnostic aids is necessary prior to their general acceptance by the medical community. Thus, the patellar glide tests should undergo formal testing to determine if they can reliably distinguish subjects with PFP from subjects without PFP.

E. Summary

PFPS remains a common problem encountered in rehabilitation medicine. Although much research has been undertaken to try and understand the underlying mechanisms of pain and dysfunction, substantial gains have not been made in the development of assessment tools for the primary clinician. There is acceptance that the lateral support system of the joint can play a role in the creation of PFPS and that the integrity of the medial and lateral support mechanisms can be adequately assessed by imaging techniques superior to the standard X-ray. However, no simple clinical test has been shown to reliably discriminate those subjects with and without PFP. A good clinical test would be one that was universally utilized by clinicians, and would give objective information to assist in prescribing the appropriate treatment regime. If the

clinical tests described above were able to do the task ascribed to them, and aid in diagnosis of PFPS as well as indicate the appropriate intervention, they would be a welcome addition to the clinical assessment of PFPS.

Chapter III

METHODS AND PROCEDURES

A. Sample

The sample consisted of two groups of 25 females each between the ages of 14-35 years and with a BMI of between 18 and 27 (See Appendix A). All subjects volunteered for the study. This age group was chosen because it is a common age group to present with PFP. Although PFP is commonly seen in subjects younger than 14 years, this age group was excluded because of skeletal immaturity. Subjects under the age of 16 were only included if menarche had commenced at least two years prior to their involvement in the study. Menarche is considered a reliable indicator of female skeletal maturity (Williams, Warwick, Dyson & Bannister, 1989). The upper limit of 35 years was chosen as degenerative changes may be present in the joint after that age (Aglietti et al., 1983). The weight limit was chosen because obesity may have made the tests more difficult to perform. All subjects were given an information sheet explaining the nature of the study and signed an informed consent form retaining the right to withdraw from the study at any time without prejudice or consequence to their medical treatment (Appendices B & C). Subjects under the age of 18 obtained written consent from their legal guardian prior to participating in the study.

Subject's in Group One were students and staff recruited from the university with no history of knee pathology requiring medical intervention. They were matched for activity level (Appendix D) and age within five years to subjects in Group Two.

Group Two consisted of individuals with patellofemoral pathology. These subjects were recruited from physical therapy clinics and hospitals, and

orthopaedic surgeons in Edmonton. Letters were sent to the clinic operators and surgeons requesting their cooperation in subject recruitment (Appendix E). The clinical physical therapist or surgeon obtained the patient's verbal consent, after which the principal investigator approached the subject, to determine whether they met the set inclusion criteria and wished to take part in the study. The subject's physician was also contacted to inform him/her of the patient's involvement in the study.

The inclusion criteria included:

1. retropatellar or peripatellar knee pain during or after activity, with ascending or descending stairs or with sitting for prolonged periods with the knee flexed
2. pain present for greater than two weeks, but less than eight years
3. ability to attain 20-25 degrees of knee flexion
4. no visible knee effusion. A positive swipe test was permissible.

Exclusion criteria included:

1. inflammation of the patellar tendon
2. previous patellar dislocation or subluxation causing giving way of the knee
3. history of knee surgery
4. history of ligamentous injury requiring medical intervention
5. history of polyarticular disease
6. direct trauma to the patella
7. greater than six treatments for their symptoms

If the subjects presented with bilateral symptoms, the most symptomatic knee was chosen. Group One was matched to the knee tested in Group Two so that there were equal numbers of left and right knees within each group.

B. Personnel

Two examiners tested all subjects without knowledge of the subject's grouping. Both examiners were physical therapists with at least three years clinical experience in outpatient orthopaedics. The principal investigator assisted with the placement of the digital calipers, and with the measurement of patellar displacement with the calipers, but did not assist with patient set up or the actual displacement technique.

C. Subject Positioning

Each examiner was responsible for preparing each subject for examination. The subjects lay supine on a plinth with both knees placed in 20-25 degrees of knee flexion, supported with a quadriceps block, and the lower extremity maintained in neutral rotation. The knee position was checked by goniometer prior to testing to ensure that the degree of knee flexion was consistent for all subjects. The lower extremities were loosely bound together with a mobilization strap to prevent lateral rotation of the leg being examined.

D. Procedure

1. Patellar Glide Test

Masking tape was placed superior to the patella on the distal portion of the QF muscle. The tape was marked with ink dividing the patella into quadrants at its widest portion, using a cloth measuring tape to ensure accuracy in establishing the quadrants. The masking tape served as a reference guide to assist the examiner in measuring the amount of patellar displacement. The use of masking tape was necessary to prevent the second examiner from seeing the previous quadrant markings.

Following the patient setup, each examiner performed two practice

measurements to familiarize the subject with the procedure. The rehearsal of the tests allowed the subjects to become familiar with the procedure and therefore enhanced their ability to relax during the measurement. Prior to commencement of the test, the subject was given a brief explanation of the procedure and was informed that she could stop the test at any time by simply giving the command "Stop". The examiner then positioned him/herself at one side of the plinth standing in line with the knee. The patella was held between the dominant thumb and index finger with the thumb being placed in the position to displace the patella. The patella was then displaced away from the examiner as far as possible using tissue resistance as a guideline (See PLATE 3.1). The examiner moved to the other side of the plinth and repeated the procedure in the opposite direction. The examiner marked his/her findings on the data sheet provided. The masking tape was removed and the same procedure repeated by the second examiner.

A positive lateral patellar glide test was defined as a lateral glide of two or more quadrants. A positive apprehension test was also considered pathological. A positive medial patellar glide test was defined as a medial glide of one or fewer quadrants (Bourne et al., 1988; Gecha & Torg, 1988; Kolowich et al., 1990).

2. Caliper Measurement of Patellar Displacement

Following the patellofemoral glide tests, the examiners measured medial and lateral patellar displacement of all subjects using a Mitutuoyo digimatic caliper, Series 500. The caliper consists of two measurement prongs, one which is stationary and one which is movable and measures the amount of displacement. This particular caliper is a precision instrument with a data processor capable of recording the movement in mm. This measurement is

PLATE 3.1 Performance of Medial Patellar Glide Test.

displayed on a digital readout (See PLATE 3.2).

Subjects remained in the same position as stated above for caliper measurement of patellar displacement. The caliper measurement consisted of having the examiner place the calipers on either side of the patella at its widest portion. The stationary prong of the caliper rested on a stabilized wooden block placed beside the patella to ensure that no movement of the prong occurred while the patella was displaced. The other prong of the caliper was placed on the side of the patella to which the patellar displacement was going to occur. The calipers were then maintained in this position by the principal investigator as the examiner displaced the patella using the same displacement procedure as used for the patellar glide tests (See PLATE 3.3). After the patella was displaced, the digital readout displayed the distance moved. The displacement was then noted and recorded on the data collection sheet by the principal investigator. The calipers were removed and the examiner and the stationary block were moved to the other side of the patella. The procedure was then repeated for the measurement of the opposite movement.

The experimental setup was such that neither examiner observed the other taking the patellar glide measurements nor conducting the caliper measurements. Testing was done in random order. To further prevent measurement bias, the subjects were placed behind a curtain with only their lower extremity exposed. Screening prevented the examiner from seeing any facial expressions or recognizing any of the participants.

Test-retest reliability of the caliper measurement was obtained in a pilot study prior to commencement of the study. Ten volunteers who met the criteria for normal knees were used in the pilot project. Examiner One performed all measurements for this project. The caliper's digital readout was covered and

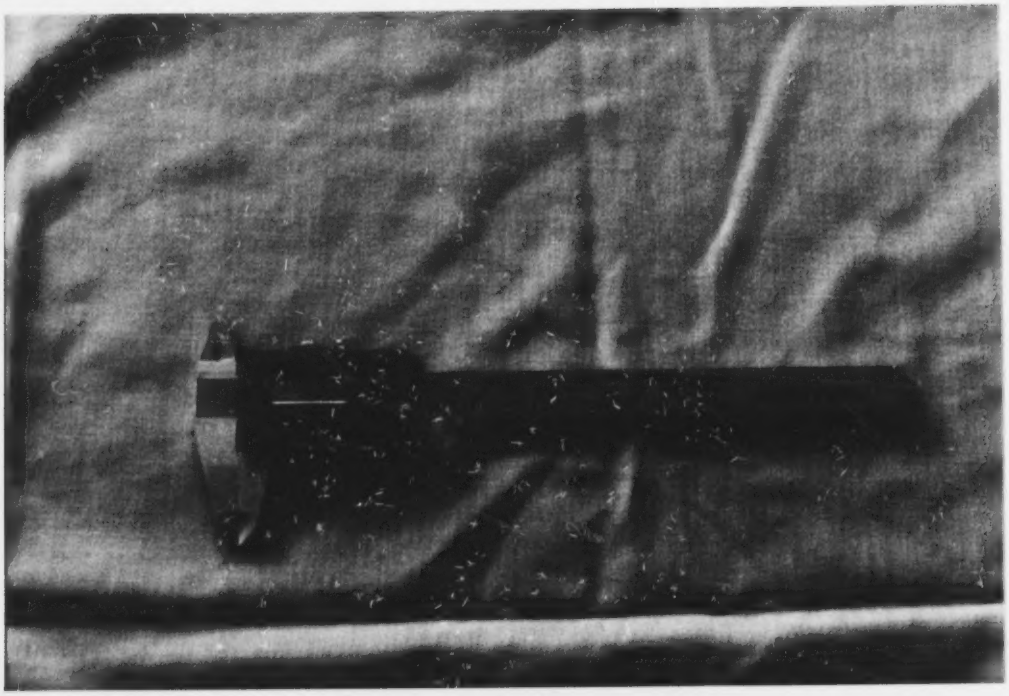


PLATE 3.2 Mitutuoyo Digital Caliper.

PLATE 3.3 Performance of Medial Patellar Displacement Measured by Caliper

Examiner Two recorded all findings so that neither the principal investigator or Examiner One could bias the results. Each measurement was performed twice in each direction with the subject maintaining her position between the first and second examination. Test-retest reliability as determined by an Intraclass Correlation Coefficient (ICC) was found to be 0.83 and 0.94 for the medial and lateral displacement of the patella respectively.

E. Data Presentation and Analysis

Four different statistical techniques were used to meet the initial four objectives of this study. To determine the interrater reliability of the medial and lateral patellar glide test, a Cohen's Kappa test was used. This test is a non-parametric test of association for nominal data that accounts for the effect of chance agreement. The medial and lateral patellar glide tests were analyzed separately to determine the proportion of cases in which the examiners had agreement. A Kappa score of between 0.4 and 0.75 can be considered to have an acceptable level of agreement (Keating, Bergmann, Jacobs, Finer & Larson, 1990).

Group differences on the medial and lateral patellar glide tests and on the two tests combined were analyzed using Yate's Corrected Chi Square tests (Norusis, 1986). When combining the results of the two tests, a positive response on either of the two patellar glide tests was designated as pathological.

The interrater reliability of patellar displacement measured by calipers was determined by the ICC. Medial and lateral patellar displacements were analyzed separately. Test-retest reliability and interrater reliability of the caliper measurement of patellar displacement would be considered acceptable if the ICC was greater than or equal to 0.8 (Currier, 1984). Group differences on the

caliper tests were analyzed with paired Student's t-tests. Paired t-tests were used because the subjects were individually matched according to age and activity level. Individual t-tests were done for both the medial and lateral patellar displacement .

The final objective of determining which of the two clinical measurements was superior in determining patients with patellofemoral pathology was not analyzed because neither measurement showed the ability to discriminate between the two groups for either of the examiners.

Chapter IV

RESULTS

A. Interrater Reliability of the Medial and Lateral Patellar Glide Tests

i) Medial Patellar Glide Test

The data from the medial patellar glide test for the two groups of subjects were combined so there was one data pool for each of the two examiners. The two examiners agreed on the rating of the subject's grouping 31 times out of a possible 50 times to obtain a Kappa score of 0.53. See Appendix F for the calculation of the Kappa score.

ii) Lateral Patellar Glide Test

For the lateral patellar glide test, the examiners reached agreement 48 times out of a possible 50 times to obtain a Kappa score of 0.96. The agreement was extremely high on this test because there were very few positive scores on the test in either of the two groups. In fact, one examiner had no positive scores for this test.

B. Discriminant Ability of the Patellar Glide Tests

i) Medial Patellar Glide Test

Each examiner's ratings for the medial patellar glide test were analyzed separately. The subject ratings by each of the examiners are found in TABLE 4.1 and TABLE 4.2. No significant difference between groups was found by either examiner (See TABLE 4.3).

ii) Lateral Patellar Glide Test

No subjects from either group were rated as positive on the lateral patellar glide test by Examiner One. Further analysis was not necessary as

there was obviously no difference between the two groups. Examiner Two rated only two subjects as positive on the lateral patellar glide test, indicating again that there was no significant difference between the two groups (See TABLE 4.4 & TABLE 4.5).

iii) Combined Patellar Glide Tests

The combined patellar glide test analysis was not done for Examiner Two as he had no positive values for the lateral patellar glide test. Therefore, the results of the combined patellar glide tests results for Examiner One would be identical to the results found for the medial patellar glide test alone (See TABLES 4.1 and 4.3).

Examiner Two's findings for the combined patellar glide tests are displayed in TABLE 4.6. No significant differences were found between the two groups (See TABLE 4.7).

TABLE 4.1

Ratings for the Medial Patellar Glide Test

for Examiner One

	Negative Test	Positive Test	TOTAL
Normal Group	13	12	25
PFP Group	10	15	25
TOTAL	23	27	50

TABLE 4.2

Ratings for the Medial Patellar Glide Test

for Examiner Two

	Negative Test	Positive Test	TOTAL
Normal Group	19	6	25
PFP Group	13	12	25
TOTAL	32	18	50

TABLE 4.3

Results of Yate's Corrected Chi Square Test

for the Medial Patellar Glide Test

Examiner	Chi Square Value	Degrees of Freedom	Probability ($P < 0.05$)
One	0.32	1	0.57
Two	2.17	1	0.14

TABLE 4.4

Ratings for Examiner Two

for the Lateral Patellar Glide Test

	Negative Test	Positive Test	TOTAL
Normal Group	24	1	25
PFP Group	24	1	25
TOTAL	48	2	50

TABLE 4.5

Results of Yate's Corrected Chi Square Test

for the Lateral Patellar Glide Test

for Examiner Two

Examiner	Chi Square Value	Degrees of Freedom	Probability ($P < 0.05$)
Examiner Two	0.00	1	1.00

TABLE 4.6

Ratings for Examiner Two

for the Combined Patellar Glide Tests

	Negative Test	Positive Test	TOTAL
Normal Group	18	7	25
PFP Group	13	12	25
TOTAL	31	19	50

TABLE 4.7

Results of Yate's Corrected Chi Square Test

for the Combined Patellar Glide Tests

for Examiner Two

Examiner	Chi Square Value	Degrees of Freedom	Probability ($P < 0.05$)
Examiner Two	1.36	1	0.24

C. Interrater Reliability of Caliper Measurement of Patellar Displacement

i) Medial Patellar Displacement

The data from all subjects were used to examine the interrater reliability of the measurement of medial patellar displacement by calipers. The results of this analysis are found in TABLE 4.8. The difference between the adjusted and unadjusted reliabilities indicates that a small systematic error was present between the two examiners.

TABLE 4.8

Means, Standard Deviations and Intraclass Correlation Coefficients for the Caliper Measurement of Medial Patellar Displacement

	Examiner One	Examiner Two
Mean (in mm)	23.25	26.57
Standard Deviation	7.20	6.77
Unadjusted Reliability	0.35	
Adjusted Reliability	0.42	

ii) Lateral Patellar Displacement

The results of the analysis of lateral patellar displacement measured by calipers are contained in TABLE 4.9. As with medial patellar displacement, a systematic error was present as the unadjusted reliability was lower than the adjusted reliability.

TABLE 4.9

Means, Standard Deviations and Intraclass Correlation Coefficients for the Caliper Measurement of Lateral Patellar Displacement

	Examiner One	Examiner Two
Mean (in mm)	18.37	23.38
Standard Deviation	5.59	4.54
Unadjusted Reliability	0.23	
Adjusted Reliability	0.52	

D. Discriminant Ability of Caliper Measurement of Patellar Displacement

i) Medial Patellar Displacement

Each examiner's results were analysed separately to see if either examiner was able to discriminate between the two groups of subjects using the measurement of medial patellar displacement by caliper (See TABLE 4.10). No significant difference was found between the two groups for either examiner. Greater differences in means were found between examiners (3.99 & 2.65 mm) than between groups (2.56 & 1.02 mm).

ii) Lateral Patellar Displacement

As with medial patellar displacement measured by caliper, both examiner's results for lateral patellar displacement were analyzed because their level of agreement was very low. No significant difference between groups was found by either examiner in the amount of lateral patellar displacement measured (See TABLE 4.11). Again, greater differences in means were found between the measurements of the two examiners than between the two groups of subjects. The greatest difference in means between groups was 1.28 mm and between examiners was 5.58 mm.

TABLE 4.10

Descriptive Statistics and Paired T-test Analysis

of Examiners One and Two

for the Measurement of Medial Patellar Displacement

by Caliper

	Examiner One		Examiner Two	
	Normal Group	PFP Group	Normal Group	PFP Group
Mean (in mm)	22.07	24.43	26.06	27.08
Standard Deviation	5.90	8.24	7.34	6.25
t-value	-1.21		-0.47	
Probability	0.24		0.64	

TABLE 4.11

Descriptive Statistics and Paired T-test Analysis

of Examiners One and Two

for the Measurement of Lateral Patellar Displacement;

by Caliper

	Examiner One		Examiner Two	
	Normal Group	PFP Group	Normal Group	PFP Group
Mean (in mm)	19.01	17.73	23.45	23.31
Standard Deviation	4.52	6.52	4.55	4.62
t-value	0.76		0.46	
Probability	0.09		0.93	

Chapter V
DISCUSSION

A. Patellar Glide Tests

I) Medial Patellar Glide Test

The interrater reliability of the medial patellar glide test was acceptable as Keating et al. (1990) defined good reliability as scoring between the range of 0.40 and 0.75. The reliability score does not indicate the number of times the examiners were correct in their subject ratings, but the number of times that the two examiners reached agreement on a subject's rating.

Neither examiner was able to discriminate between the two groups of subjects using the guidelines of the medial patellar glide test. The finding that no significant difference existed between the two groups does not support the suggestions of Gecha and Torg (1990), Kolowich et al. (1990), and Bourne et al. (1988), who stated that patellar mobility of one or fewer quadrants should be considered indicative of a hypomobile lateral retinaculum. Based on the findings of this study, which was an examiner blinded design with trained examiners, this test should not be used as one of the most important indicators of whether or not a lateral retinacular release should be performed as was suggested by Gecha and Torg (1990) and Kolowich et al. (1990). If the medial patellar glide test was used as the most important indicator of when a lateral retinacular release should be done, several patients could have their retinaculum released when it may not be the source of their anterior knee pain. Conversely, several patients with PFP may not have the surgical intervention even if it is indicated, if the decision was primarily based on the findings of this test. With reports in the literature of postoperative medial patellar subluxations and even dislocations, it is essential that a test is actually able to discern

differences between subjects with a symptomatic hypomobile lateral retinaculum and subjects without knee pain before making a decision on the correct surgical intervention (Hughston & Deese, 1988; Busch & DeHaven, 1989; Miller et al., 1991).

It is interesting to note that Examiner One showed a tendency to identify the pathological subjects, rating 15 out of 25 PFP subjects as positive, while Examiner Two showed a tendency to identify the normal subjects, rating 19 out of 25 normal subjects as negative. Explanation for this difference in subject rating between the examiners may be explained by examining the raw data of the caliper measurement of patellar displacement (See Appendix G). Examiner Two measured consistently higher movements than did Examiner One on both medial and lateral caliper measurements. This finding may indicate that Examiner Two was pushing slightly harder than Examiner One during all testing procedures.

The possibility that Examiner Two was pushing the patella harder and identified more of the normal subjects, while Examiner One identified more pathological subjects with a gentler push may suggest that a significant difference could have existed between the two groups if the mobility criterion had been more stringent for abnormal patellar mobility. None of the authors who described the medial patellar glide test described how the definition of pathological movement was determined (Bourne et al., 1988; Gecha & Torg, 1990; Kolowich et al., 1990). This study, which used blinded examiners trained in performing the patellar glide test, determined that no significant difference existed between subjects with PFP and subjects without PFP. Perhaps if the criterion for abnormal medial patellar mobility had been set at less than one quadrant rather than one or fewer quadrants, more of the examiner's ratings may have been negative. Although this increase in negative findings may have

occurred in both groups, it is possible that more negative findings would have occurred in Group One. Further study may indicate whether or not changing the pathological criteria would discern between PFP and normal subjects.

As well, the consistent difference between examiners may indicate that the force used to perform the test should be standardized by training sessions prior to clinical use. By using a small force transducer attached to the thumb as an objective measurement tool, the examiner may be able to learn to reliably judge the end ROM of the patellar glide.

Another reason for not finding differences between groups may be the fact that no male subjects were used. Larson, Baum and Mudholker (1987) noted that males have less general mobility than females, so the inclusion of males in the study may have resulted in more positive tests. Although it is expected that both males with PFP and without PFP would have less mobility, a significant difference may have been found between the two groups.

The medial patellar glide test addresses only the glide of the patella. McConnell (1986) and Kolowich et al. (1990) also mention the importance of assessing the tilt of the patella. Schutzer et al. (1986) suggest measuring the patellar tilt angle with a CT scan to assess patellar tilt. They speculate that a positive patellar tilt angle indicates a hypomobile lateral retinaculum. Both McConnell (1986) and Kolowich et al. (1990) mention a clinical measurement for patellar tilt, but neither of these suggested clinical measurements have been tested for their reliability and discriminant ability. If both patellar tilt and glide could be adequately measured, one could determine if restricted tilt and glide of the patella occur in conjunction with each other, or if they are separate components which should be measured separately. McConnell (1986) has speculated that these components may indicate that different areas of the retinaculum are hypomobile. She suggests that when the patellar glide is

restricted, the SOR is tight whereas if patellar tilt is present, the DTR is hypomobile. McConnell's speculations appear to be based upon clinical experience.

Finally, in regards to the medial patellar glide test, both examiners made mention of the quality of patellar movement. In some subjects, although the amount of glide fell within the normal guidelines, the patella did not glide smoothly. Instead, there was audible clicking and/or uneven gliding as the patella was displaced in a medial direction. Both examiners noted, that as clinicians, they would have graded the patellar mobility as abnormal in spite of the fact that the degree of glide fell within the normal guidelines. This judgement would be based solely on their previous clinical experience in patellofemoral assessment. However, no data was gathered on the number of subjects who presented with this finding.

This study has indicated that the medial patellar glide test is unable to discriminate between subjects with PFP and subjects without PFP. Based on that conclusion, it does not seem appropriate to state that the presence of a positive medial patellar glide test should be the most important indicator of when a lateral retinacular release should be performed as suggested by Gecha and Torg (1990) and Kolowich et al, (1990).

ii) Lateral Patellar Glide Test

The very high reliability of the lateral patellar glide test was found simply because so few subjects tested positive on the test. The reason for such a low occurrence may be explained by the subject criteria which excluded from the study any subjects who had had: a) previous major patellar subluxation causing giving way of the knee, or b) previous patellar dislocation. Had these criteria not been used, it is possible that there would have been more positive scores.

There were two reasons for including these criteria. Firstly, the author believed that subjects who met those criteria would present with a positive apprehension test which would have blocked the scoring of the lateral patellar glide test. The second reason was to avoid an occurrence of a major subluxation or dislocation during the testing procedure.

In summary, although the reliability score was extremely high, due to a relative non-occurrence of positive scores for both examiners, the lateral patellar glide test did not discriminate between the two groups of subjects. This result may have been different had the exclusion criteria of patellar subluxation and dislocation not been used.

iii) Combined Patellar Glide Test

The results of the combined patellar glide test did not vary significantly from the results of the medial patellar glide test. This is probably due to the few positive scores found on the lateral patellar glide test.

Several factors may have contributed to the negative findings of this study as discussed previously. An additional factor which may have led to the negative findings is the sample which was used. Although the subjects met all required inclusion criteria for the study, it is possible that they did not represent a typical PFPS population. No other physical data such as a Q-angle measurement or x-ray measurements were collected, nor was a full physical assessment of the subject performed. Had these data been included, more conclusions may have been drawn as to whether or not Group Two was typical of a PFPS population, as it is known that differences do exist between a PFP population and a normal population on the Q-angle and X-ray measurements (Merchant et al., 1974; Aglietti et al., 1983). However, it is important to point out that the PFP subjects examined in these previous studies were patients who

had not responded to conservative measures and were being considered for surgical intervention. The majority of PFP patients will respond well to conservative measures, so it is possible that the subjects used by Merchant et al (1974) and Aglietti et al. (1983) do not represent a typical PFP population, but instead represent a subset of the PFP population with more severe symptoms (Paulos et al., 1980; Fisher, 1986). The subjects used by Kolowich et al. (1990) and Gecha and Torg (1990) also probably do not represent the typical PFP population. These subjects were also candidates for surgical intervention as conservative measures had not been successful. The other physical data mentioned above, were not examined in this study because the author was interested in the discriminant ability of the patellar glide tests. Gecha and Torg (1990) and Kolowich et al. (1990) both suggested that the medial patellar glide test was one of the most important indicators of whether or not a lateral retinacular release should be performed, so other data was not deemed as important for the results of the study.

The normal subjects used as matches for the PFP subjects may also not constitute a normal sample. The only required exclusion criterion for these subjects was medical intervention for any knee pain or injury. Again, no further data was collected on the normal subjects to determine if their Q-angle measurement, x-ray measurements, or their physical assessment fell within normal guidelines. Merchant et al. (1974) and Aglietti et al. (1983) have published values expected in a normal population in the magnitude of their Q-angle measurements, and several X-ray measurements for patellar incongruency. Thus, had this information also been gathered, it may have been possible to see if Group One was representative of a normal population. There was no reason, however, to believe that Group One was not representative of the normal population as this sample consisted of subjects from a varying age

range and activity level.

The positioning of the subject may have also affected the findings of the patellar glide tests. Several different degrees of knee flexion have been used in measuring patellar glide. McConnell (1986) performed her assessment measurements in zero degrees of knee flexion. Gecha and Torg (1990) performed their test in 15 to 20 degrees of knee flexion while Bourne et al. (1988) and Kolowich et al. (1990) suggested that the test should be performed in 20 to 30 degrees of knee flexion. A range of 20 to 25 degrees of knee flexion was chosen for this study based on these authors' descriptions of the test position. At 20 degrees of knee flexion, the patella should be moving into the trochlear groove, but should still have some medial and lateral mobility before settling completely into the bony confines of the groove (Grana & Kriegshauser, 1985). The amount of knee flexion will affect the degree of tissue tension acting on both the medial and lateral retinaculum. At zero degrees, there would be minimal tissue tension and the patella should be freely mobile. As the knee moves towards 30 degrees of knee flexion, the tissue tension should increase, with the amount of increased tension dependent upon the individual's anatomy (Fulkerson, 1989). Thus, it is possible that if less than 20 degrees of knee flexion had been used, more of Group One would have had negative results on the medial patellar glide test. Conversely, if 25 to 30 degrees of knee flexion had been used, more of Group Two could have scored positive on the test. The reverse would have been true for the lateral patellar glide test.

B. Caliper Measurement of Patellar Displacement

In a pilot study of ten subjects with normal knees, the test-retest reliability for caliper measurement was found to be very good for both the medial and lateral displacement measurements. This measurement may have been very

high because the subjects did not change position between measurements. However, intrarater reliability is generally higher than interrater reliability (Rothstein, 1985).

Very poor interrater reliability was found for the caliper measurement of both medial and lateral patellar displacement. The unadjusted reliability was even lower than the adjusted reliability indicating that a systematic error was present. This systematic difference between the two examiners was probably due to Examiner Two consistently measuring higher displacement values than Examiner One on both tests. The raw data consistently showed higher measurements for Examiner Two in all caliper measurements (Appendix G). There may also have been variations between the two examiners in the way they placed the limb and applied the calipers. However, in a clinical setting, an examiner would do the entire task independently. Thus, the reliability of the total test rather than simply the excursion of the calipers was tested in this study.

The two examiners may have also positioned their hands differently to direct the patellar displacement. In the medial patellar glide test, a more inferiorly placed hand may have encouraged more medial rotation of the apex of the patella while a more superiorly placed hand may have led to more lateral rotation of the patellar apex. The opposite rotational effect would have occurred with the lateral patellar glide test. Patellar tilt may also be affected by hand positioning, although it is more difficult to determine the specific reaction of the patellar tilt to a force which originated more superiorly or inferiorly along the patellar border. The examiners used in this study were specifically trained to perform the caliper measurements. One would expect even poorer reliability in a clinical setting.

Because the caliper is designed to measure linear movements, and patellar glide may not be strictly linear, but may involve some degree of patellar

tilt or rotation as discussed above, the caliper measurements may have been more vulnerable to measurement error than the patellar glide tests. This measurement error could have occurred with the calipers because the patellar displacement was measured from the farthest side of the patella from which the movement was being directed. The patellar glide tests, on the other hand, measured the amount of displacement occurring from the adjacent edge of the patella from which movement was being directed. The far edge of the patella appears more likely to rotate or tilt in reaction to a slightly different pressure than the patella's adjacent edge.

Neither of the examiners were able to discriminate differences in medial or lateral patellar displacement between the two groups of subjects, so the caliper will obviously not be a useful tool in determining if patellar mobility is normal or abnormal. However, the caliper measurement of patellar displacement would be useful as a retest measurement by the same examiner because of its high intrarater reliability. Measurements done by different examiners should not be compared to each other because of the low interrater reliability found in this study.

It remains a challenge to assess PFPS and determine the primary structure or structures which are leading to patellofemoral dysfunction, and pain. The lateral retinaculum has held the attention of physicians and clinicians for the past 10 to 15 years. It is important to remember as the patellofemoral joint is assessed, that the mobility of the supporting retinaculi is not the only factor contributing to PFP. There are several factors which may contribute to the development of PFPS. These factors generally lead to an increased lateral vector at the knee joint, and predispose an individual to adaptive shortening of the knee's lateral structures. However, there is no certainty that the lateral retinaculum will become hypomobile or the medial retinaculum hypermobile.

As well, it is interesting to note that several subjects in the normal group also scored positive on the medial patellar glide test. Overlap between a normal sample and a PFP sample is a typical finding of tests presently available to aid in determining the cause of PFP. However, despite overlap between samples, these other physical measurements have still been able to discern significant differences between the two samples (Aglietti et al., 1983; Schutzer et al., 1986). Again, it is important to indicate that the PFP subjects used in these studies were candidates for surgical intervention, so they may not be representative of a typical PFP population.

There are also patients with PFPS who may have problems with their dynamic medial support in the form of VMO dysplasia or atrophy (Paulos et al., 1980; Kennedy et al., 1982). These patients would not have been properly assessed with just the measurement of passive retinacular structures because their problem lies in the dynamic support system. An assessment must also be done of the tracking pattern of the patella to determine if the problem is dynamic in nature. If the sample used in this study had more subjects with medial dynamic support problems than static lateral support problems, no differences would be expected to be found between the two groups.

The need for more objective measurements in the assessment of PFPS has been noted repeatedly in the literature (Elton et al., 1985; Chesworth, Culham, Tata & Peat, 1988; Callaghan & Baltzapoulos, 1992). However, before new measurements techniques can be accepted and used universally, it is important to know if they add information to the assessment and treatment regimes for patellofemoral pathology. The medial patellar glide test has been suggested by several authors to be one of the most important indicators of when a lateral retinacular release is appropriate (Gecha & Torg, 1990; Kolowich et al., 1990). This study does not support their suggestions, and indicates that further

investigation is necessary before deciding upon the usefulness of these tests. Another possibility is that the patellar glide tests could predict response to treatment in a subset of the PFP population being considered for surgery. It would be interesting to see if positive findings on the patellar glide tests correlate with abnormal findings on the more advanced imaging techniques of CT scan and MRI.

The findings of this study point out the importance of testing a clinical tool before suggesting it be accepted by the health care professional. Clark's test was in use for several years before Gaughwin (1985) reported that it was not a specific indicator of retropatellar pathology McConnell (1986) has suggested that her assessment is able to determine abnormal positioning and movement of the patella, and that her treatment protocol can correct these abnormalities. With this study's findings of significant overlap in the mobility of the patella between normal subjects and subjects with PFP, McConnell's work must be interpreted with care. No formal testing has been done to date to determine if differences exist between subjects with PFP and subjects with no history of knee pathology in the positioning of their patella. The present study is the first to compare the passive movement of the patella in persons with and without PFP. The results indicate that there is no difference in this movement and suggest that there may also be no difference in patellar position in these to groups.

C. Clinical Recommendations

i) Medial Patellar Glide Test

Further study is required to determine the ability of the medial patellar glide test to detect the presence of a hypomobile lateral retinaculum. As the criterion is set now, both subjects with PFP and subjects without PFP can

present with a positive test. If the criterion is stricter for the test, a significant difference may be found to exist between the two groups. Based on the present findings, surgical intervention should not be based on the presence of a positive medial glide test as this test was also positive in a number of the subjects without PFP.

ii) **Caliper Measurement of Patellar Displacement**

Based on the findings of this study, the caliper does not appear to be an effective tool to determine if abnormal mobility of the patella is present. It may, however, be used as a tool for repeat measurements by one examiner. Thus, it could be used as a measurement preoperatively or pretreatment, and again postoperatively or posttreatment, to see if any changes had occurred in patellar mobility due to the intervention.

Chapter VI

SUMMARY AND CONCLUSIONS

A. Summary

The objectives of this study were to determine the interrater reliabilities and discriminant abilities of two methods of measurement of medial and lateral patellar mobility. Two groups of 25 females, between the ages of 14 and 35 years, made up the study population. One group had PFP and met all required conclusion criteria while the other group had normal knees and was matched to the PFP group on age and activity level. Two therapists examined each of the subjects once for each of the outcome measures. The therapists were blinded to the subject's grouping and performed each measurement independently of each other.

The two methods of testing were the medial and lateral patellar glide tests and medial and lateral patellar displacement measured by calipers. Cohen's Kappa test was used to determine the interrater reliability of the patellar glide tests while the Yate's Corrected Chi Square test was used to determine their discriminant ability. Medial and lateral patellar glide tests were analysed separately as well as with their combined results. The caliper measurement of patellar displacement was analysed with an ICC for interrater reliability and paired t-tests for their discriminant ability. A pilot project was performed for the caliper measurement of patellar displacement, and the results of this project was also analysed with an ICC.

B. Conclusions

Based on the study undertaken and described above, the following conclusions were made:

1. The medial patellar glide test had acceptable interrater reliability as measured by a Kappa score of 0.53.
2. The lateral patellar glide test had very high interrater reliability due to a relative non-occurrence of a positive score.
3. Neither examiner was able to discriminate between the two groups of subjects using either the medial or lateral patellar glide tests. Combining the results of the two tests made no difference in the test's ability to discriminate between the two groups of subjects.
4. The test-retest reliability of the caliper measurement of medial and lateral patellar displacement was high measuring 0.83 and 0.94 respectively.
5. The interrater reliability of the medial and lateral patellar displacement as measured by calipers was very low. A systematic error was found to occur between the two examiners.
6. Neither of the examiners were able to discriminate between the two groups of subjects for either the medial or lateral patellar displacement measurement.

On the basis of these conclusions, it can be stated that, at the present time, no clinical method exists to determine abnormal medial and lateral patellar mobility and distinguish between subjects with PFP and subjects without PFP.

References

Aglietti P, Insall JN, Cerulli G: Patellar Pain and Incongruence I: Measurements of Incongruence. Clin Orthop 176: 217-224, 1983

Betz RR, Lonergan R, Patterson R, Litton J, Yucha T, Boal R: The Percutaneous Lateral Retinacular Release. Orthopaedics 5: 57-62, 1982

Bose K, Kanagasuntheram R, Osman MBH: Vastus Medialis Oblique: An Anatomic Study. Orthopedics 3: 880-883, 1980

Bourne MH, Hazel WA, Scott SG, Sim FH: Anterior Knee Pain. Mayo Clin Proc 63: 482-491, 1988

Busch MT, DeHaven KE: Pitfalls of the Lateral Retinacular Release. Clin Sports Med 8: 279-290, 1989

Callaghan MJ, Baltzopaulos V: Anterior Knee Pain: The Need for Objective Measurement. Clin Biomech 7: 67-74, 1992

Carson WG, James SL, Larson RL, Singer KM, Winternitz WW: Patellofemoral Disorders: Physical and Radiographic Evaluation. Part II: Radiographic Examination. Clin Orthop 185: 165-177, 1984

Chesworth BM, Culham EG, Tata GE, Peat M: Validation of Outcome Measures in Patients with Patellofemoral Pain Syndrome. J Orthop Sports Phys Ther 10: 302-308, 1989

Currier DP: Elements of Research in Physical Therapy, ed. 2, Baltimore, William and Wilkins, 1984, p 162

Delgado-Martins H: A Study of the Patella Using Computerized Tomography. J Bone Joint Surg 61-B: 443-444, 1979

Dzioba RB: Diagnostic Arthroscopy and Longitudinal Open Lateral Retinacular Release. Am J Sports Med 18: 343-348, 1990

Elton K, McDonough K, Savinar E, Jensen G: A Preliminary Investigation: History, Physical, and Isokinetic Exam Results versus Arthroscopic Diagnosis of Chondromalacia Patella. J Orthop Sports Phys Ther 7: 115-123, 1985

Fairbank HAT: Internal Derangement of the Knee in Children and Adolescents. Proc Roy Soc Med 427: 11-18, 1937

Fisher RL: Conservative Treatment of Patellofemoral Pain. Orthop Clin North Am 17: 269-272, 1986

Fox T: Dysplasia of the Quadriceps Mechanism: Hypoplasia of the Vastus Medialis Muscle as Related to the Hypermobile Patella Syndrome. Surg Clin North Am 55: 199-226, 1975

Francis RS, Scott DE: Hypertrophy of the Vastus Medialis in Knee Extension. Phys Ther 54: 1066-1070, 1974

Fulkerson JP: Awareness of the Retinaculum in Evaluating Patellofemoral Pain. Am J Sports Med 10: 147-149, 1982

Fulkerson JP: Evaluation of the Peripatellar Soft Tissues and Retinaculum in Patients with Patellofemoral Pain. Clin Sports Med 8: 197-201, 1989

Fulkerson JP, Gossling HR: Anatomy of the Knee Joint Lateral Retinaculum. Clin Orthop 153: 183-188, 1980

Fulkerson JP, Schutzer, S, Ramsby G, Bernstein R: Computerized Tomography of the Patellofemoral Joint Before and After Lateral Release or Realignment. Arthroscopy 3: 19-24, 1987

Fulkerson JP, Shea K: Mechanical Basis for Patellofemoral Pain and Cartilage Breakdown IN Articular Cartilage and Knee Joint Function: Basic Science and Arthroscopy. Ewing JW (Ed.), Raven Press Ltd, New York, 1990, 93-101

Fulkerson JP, Tennant R, Jaivin JS, Grunnet M: Histologic Evidence of Retinacular Nerve Injury Associated with Patellofemoral Malalignment. Clin Orthop 197: 196-205, 1985

Fulkerson JP, & Hungerford DS: Disorders of the Patellofemoral Joint, ed 2, Baltimore, Williams and Wilkins, 1990, 1-15, 25-39, 102-105, 115, 124, 234

Gaughwin CG: The Value of Clark's Sign in Diagnosing Chondromalacia Patellae. Manipulative Therapist's Association of Australia 4th Biennial Conf Proc, Brisbane, 404-407, 1985

Gecha SR, Torg JS: Clinical Prognosticators for the Efficacy of Retinacular Release Surgery to Treat Patellofemoral Pain. Clin Orthop 253: 203-208, 1990

Goodfellow JW, Hungerford DS, & Woods C: Patellofemoral Joint Mechanics and Pathology II: Chondromalacia Patella. J Bone Joint Surg 58-A: 291-299, 1976

Grana WA, Kriegshauser LA: Scientific Basis of Extensor Mechanism Disorders. Clin Sports Med 4: 247-257, 1985

Hallisey MJ, Doherty N, Bennett WF, Fulkerson JP: Anatomy of the Junction of the Vastus Lateralis Tendon and the Patella. J Bone Joint Surg 69-A: 545-549, 1987

Health and Welfare Canada: Promoting Healthy Weights: A Discussion Paper. p 6-7, 1988

Hoke BR: Patellofemoral Compression in Evaluation of the Knee. Phys Ther 61: 738, 1981

Huberti HH, Hayes WC: Patellofemoral Contact Pressures: The Influence of Q-Angle and Tendofemoral Contact. J Bone Joint Surg 66-A: 715-724, 1984

Hungerford DS, Barry M: Biomechanics of the Patellofemoral Joint. Clin Orthop 144: 9-15, 1979

Hungerford DS, Lennox DW: Rehabilitation of the Knee in Disorders of the Patellofemoral Joint: Relevant Biomechanics. Orthop Clin North Am 14: 397-402, 1983

Hughston JC, Deese M: Medial Subluxation of the Patella as a Complication of Lateral Retinacular Release. Am J Sports Med 16: 383-388, 1988

Insall J: Current Concepts Review: Patellar Pain. J Bone Joint Surg 64-A: 147-152, 1982

Insall JN, Aglietti P, Tria AJ: Patellar Pain and Incongruence II: Clinical Application. Clin Orthop 176: 225-232, 1983

Johnson RP: Lateral Facet Syndrome of the Patella. Clin Orthop 238: 148-158, 1989

Keating JC, Bergmann TF, Jacobs GE, Finer BA, Larson K: Interexaminer Reliability of Eight Evaluative Dimensions of Lumbar Segmental Abnormality. JMPT 13: 463-470, 1990

Kennedy JC, Alexander IJ, Hayes KC: Nerve Supply of the Human Knee and It's Functional Importance. Am J Sports Med 10: 329-335, 1982

Kolowich PA, Paulos LE, Rosenberg TD, Farnsworth S: Lateral Release of the Patella: Indications and Contraindications. Am J Sport Med 18:359-365, 1990

Kramer PG: Patella Malalignment Syndrome: Rationale to Reduce Excessive Lateral Pressure. J Orthop Sports Phys Ther 8: 301-309, 1986

Kujala UM, Osterman K, Kormano M, Komu M, Schlenzka D: Patellar Motion Analyzed by Magnetic Resonance Imaging. Acta Orthop Scand 60: 13-16, 1989

Larson LG, Baum J, Mudholker GS: Hypermobility: Features and Differential Incidence Between Sexes. Arthr Rheum 30: 1426-1430, 1987

Larson RL, Cabaud HE, Slocum DB, James SL, Keenan T, Hutchinson T: The Patellar Compression Syndrome. Clin Orthop 134: 158-167, 1978

Leslie IJ, Bentley G: Arthoscopy in the Diagnosis of Chondromalacia Patellae. Ann Rheum Dis 37: 540-547, 1978

LeVeau BF, Rogers C: Selective Retraining of the Vastus Medialis Muscle Using EMG Biofeedback. Phys Ther 60: 1410-1415, 1980

Lieb FJ, Perry J: Quadriceps Function: An Anatomical and Mechanical Study Using Amputated Limbs. J Bone Joint Surg 50-A: 1535-1548,1968

Lund F, Nilsson BE: Arthroscopy of the Patellofemoral Joint. Acta Orthop Scand 51: 297-302, 1980

Malek MM, Mangine RE: Patellofemoral Pain Syndromes: A Comprehensive and Conservative Approach. J Orthop Sports Phys Ther 2: 108-116, 1981

Martinez S, Korobkin M, Fondren FB, Hedlund LW, Goldner JL: Computed Tomography of the Normal Patellofemoral Joint. Invest Radiol 18: 249-253, 1983

McConnell J: The Management of Chondromalacia Patellae: A Long Term Solution. Austral J Physiother 32: 215-223, 1986

Merchant AC, Mercer RL: Lateral Release of the Patella. Clin Orthop 103: 40-45, 1974

Merchant AC, Mercer RL, Jacobsen RH, Cool CR: Roentgenographic Analysis of Patellofemoral Congruence. J Bone Joint Surg 56-A: 1391-1396, 1974

Miller PR, Klein RM, Teitge RA: Medial Dislocation of the Patella. Skeletal Radiol 20: 429-431, 1991

Morrissey MC: Reflex Inhibition of Thigh Muscles in Knee Injury. Sports Med 7: 263-276, 1989

Norusis MJ: SPSS/PC+ for the IBM PC/XT/PT. Chicago, SPSS Inc., 1986

Paulos L, Rusche K, Johnson C, Noyes FR: Patellar Malalignment: A Treatment Rationale. Phys Ther 60: 1624-1632, 1980

Reider B, Marshall JL, Ring B: Patellar Tracking. Clin Orthop 157: 143-148, 1981

Reider B, Marshall JL, Koslin B, Ring B, Girgis FG: The Anterior Aspect of the Knee: An Anatomical Study. J Bone Joint Surg 63-A: 351-356, 1981

Rothstein JM: Measurement and Clinical Practice: Theory and Application IN Measurement in Physical Therapy, Rothstein JM (Ed) ed.1, New York, Churchill Livingstone, 1985, 1-46

Rusche K, Mangine RE: Pathomechanics of Injury to the Patellofemoral and Tibiofemoral Joint, IN Physical Therapy of the Knee, Mangine RE (Ed),ed 1, New York, Churchill Livingstone, 1988, 31-41

Spencer JD, Hayes KC, Alexander IJ: Knee Joint Effusion and Quadriceps Inhibition in Man. Arch Phys Med Rehab 65: 171, 1984

Schonholtz GH, Zahn MG, Magee CM: Lateral Release of the Patella. Arthroscopy 3: 269-72, 1987

Schutzer SF, Ramsby GR, Fulkerson JP: The Evaluation of Patellofemoral Pain Using Computerized Tomography: A Preliminary Study. Clin Orthop 204: 286-293, 1986

Seto JL, Orofino AS, Morrissey MC, Medeiros JM, Mason MJ: Assessment of Quadriceps and Hamstring Strength. Knee Ligament Stability, Functional and Sports Activity Levels Five Years After Anterior Cruciate Ligament Reconstruction. Am J Sports Med 16: 170-180, 1988

Terry GC, Hughston JC, Norwood LA: The Anatomy of the Iliopatellar Band and the Iliotibial Tract. Am J Sports Med 14: 39-45,1986

Thiranagama R: Nerve Supply of the Human Vastus Medialis Muscle. J Anat 170: 193-198, 1990

Tiberio D: The Effect of Excessive Subtalar Joint Pronation on Patellofemoral Mechanics: A Theoretical Model. J Orthop Sports Phys Ther 9: 160-165,1987

Warren LF, Marshall JL: The Supporting Structures and Layers on the Medial Side of the Knee: An Anatomical Analysis. J Bone Joint Surg 61-A: 56-62, 1979

Williams PL, Warwick R, Dyson M, Bannister LH: Gray's Anatomy. ed. 37, New York, Churchill Livingstone, 1989, 439

Wise HH, Fiebert IM, Kates JL: EMG Biofeedback as Treatment for Patellofemoral Pain Syndrome. J Orthop Sports Phys Ther 6: 95-103, 1984

APPENDIX A:

BODY MASS INDEX (BMI) SCALE

$$BMI = \frac{\text{weight (in kilograms)}}{(\text{Height})^2 \text{ (in meters)}}$$

ZONE A: Less than 20

ZONE B BMI: Between 20-25

Zone C BMI: Between 25-27

The BMI is considered to be the most satisfactory index of fat density based on height and weight , in the absence of direct measurement of fat density. Zone B is considered to have the lowest occurrence of morbidity and mortality. Zones A and C may lead to health problems in some people, but is still considered to be within the acceptable range, according to Health and Welfare Canada. All subjects for this study will have a BMI which falls within Zone A, Zone B or Zone C.

Taken From: Health and Welfare Canada: Promoting Healthy Weights: A Discussion Paper. p 6-7, 1988

APPENDIX B:

INFORMATION SHEET

INFORMATION SHEET:

THESIS TITLE: Interrater Reliability and Discriminant Ability of Clinical Measurement of Patellar Mobility

Principal Investigator: Lauren Beaupre
Master's Student
Department of Physical Therapy
Corbett Hall, University of Alberta
435-1794

Supervisor: Dr. Donna Ford
Associate Professor
Department of Physical Therapy
Corbett Hall, University of Alberta
492-5971

Thank you for your interest in my study. The purpose of this study is to examine the usefulness of two tests used in the physical therapy clinic for measuring movement of the kneecap. We will be comparing the recordings of a commonly used but less specific measuring tape technique with those of a more precise digital caliper. Neither test is invasive.

The tests will require you to attend one session at Corbett Hall which should take no more than one hour of your time. The testing session will consist of having one knee examined by two experienced examiners. Each examiner will perform the two tests. The tests should not cause pain either during or after the session. If you experience discomfort and wish for the test to stop, you have only to say "Stop" and the procedure will end immediately. The examiners will not know whether or not you have knee pain present prior to the testing session, so it is important that you not comment on the condition of your knee before the session.

Your involvement in this study is voluntary and your decision to participate in it or not, will in no way affect your medical treatment. Your physician will be notified if you decide to volunteer for the study. Any parking expenses incurred while attending a testing session will be reimbursed. I would like to take this opportunity to thank you for your interest in my research project as it's success is dependent on your involvement. If you have any further questions, I would be very happy to answer them. Please contact me at the given telephone number and I will get back to you as soon as possible.

APPENDIX C:

INFORMED CONSENT FORM

INFORMED CONSENT FORM:

THESIS TITLE: Interrater Reliability and Discriminant Ability of Clinical Measurement of Patellar Mobility

Principal Investigator: Lauren Beaupre
Master's Student
Department of Physical Therapy
Corbett Hall, University of Alberta
435-1794

Supervisor: Dr. Donna Ford
Associate Professor
Department of Physical Therapy
Corbett Hall, University of Alberta
492-5971

I,_____, do consent to participate in a study conducted by Lauren Beaupre, Master's student, Department of Physical Therapy, University of Alberta. The purpose of the study is to test the usefulness of tests commonly used to assess the movement of the kneecap. Subjects will be placed in one of two groups dependent on whether or not they have knee pain.

I will be asked to attend one testing session at Corbett Hall where my kneecap will be moved by two experienced examiners. The movement of my kneecap will be measured by each examiner using a measuring tape and a digital caliper. I should experience minimal or no pain either during, or after the testing session and the possibility of injury to the knee from the testing procedures is remote. If I experience any pain during the testing session, I may say "Stop" and the procedure will stop immediately. It is important that the examiners be unaware of whether or not I have a problem with my knee joint, so I will not make any comments to them regarding the condition of my knee prior to the testing session. The testing session should require no greater than one hour of my time.

The information that will be obtained in this study and which bears my identification will only be known to the principal investigator. Any information that is published or presented at conferences will not refer to me by name, but only by number when necessary. Data will be stored confidentially in a locked filing cabinet and will be destroyed one year following the completion of data collection.

I understand that the principal investigator will be happy to answer all of my questions at any time. I may decline to enter into this study and I may withdraw from this study at any time without prejudice or consequence to my medical treatment.

With my signature below, I indicate that I understand all that will be required of me, and I acknowledge receipt of a copy of this consent form.

_____ _____
Signature of Subject Signature of Investigator

_____ _____
Date Signature of Witness

APPENDIX D:

ACTIVITY LEVEL SCALE

Activity Level Scale

COMPETITIVE: Participation in a sports activity 6-7 times/week and/or regular participation in organized competition or activity of similar intensity

RECREATIONAL: Participation in a sports activity 3-5 times/week or 2 times/week for greater than 2 hours/session. Participation in seasonal sports (i.e. skiing) an average of 5 or more days/month

WEEKEND: Participation in a sports activity 2 or fewer times/week with each session lasting approximately 1 hour. Participation in seasonal sports (i.e. skiing) an average of 4 or less days/month

SEDENTARY: No regular involvement in a sports activity

(Adapted from: Seto JL, Orofino AS, Morrissey MC Medeiros JM, Mason MJ: Assessment of Quadriceps and Hamstring Strength. Knee Ligament Stability, Functional and Sports Activity Levels Five Years After Anterior Cruciate Ligament Reconstruction. Am J Sports Med 16: p 178, 1988)

APPENDIX E:

LETTER TO PHYSICIANS AND THERAPISTS

Dear Clinician/Physician;

I am writing to inform you of my intent to undertake a research project for my Master's of Science degree in Physical Therapy at the University of Alberta. The purpose of this letter is to ask for your cooperation in finding appropriate subjects for my project. The aim of my research is to test the reliability and discriminant ability of the patellar glide tests used in the assessment of patients with patellofemoral pain. A copy of my research proposal is available upon request.

To briefly summarize my proposal, I will be testing female subjects with patellofemoral pain and female subjects without knee pathology to see if the patellar glide tests reliably discriminate between the two groups. In order to meet this purpose, I require the assistance of 25 subjects with patellofemoral pain who meet the criteria contained in the research proposal.
The criteria will include:

1. retropatellar or peripatellar knee pain during or post activity, with ascending or descending stairs, or with sitting for prolonged periods with the knee flexed
2. pain present for greater than two weeks but less than eight years
3. ability to attain 20-25 degrees of knee flexion
4. no visible knee effusion. A positive swipe test will be permissible.
5. no inflammation of the patellar tendon
6. no previous patellar dislocation or subluxation
7. no history of knee surgery
8. no history of ligamentous injury requiring medical intervention
9. no polyarticular disease
10. no history of direct trauma to the patella
11. no greater than six treatments for their symptoms
12. between the ages of 16-35 years
13. obtain a score of 27 or less as measured by the Body Mass Index

If you are interested in assisting me and are aware of subjects who appear appropriate, I would ask that you approach these subjects to obtain their consent for me to contact them by phone and explain the nature of my research. It is important that they be asked to participate in the project as soon after assessment as possible in order that testing may be done before they have too many treatments. The subjects will be paid for all parking expenses and the time commitment should be no greater than one hour. The test is non-invasive and has minimal risk to the subjects. The subject's physician will also be contacted to inform him/her of his patient's involvement in the study.

Please feel free to contact me at 435-1794 to discuss any concerns or questions you may have regarding this proposal. Data collection should commence in the early part of November 1991. I will be contacting you shortly to determine whether your clinic will be interested in assisting me in completing my research.

Yours truly,

Lauren Beaupre
M.Sc. Candidate

APPENDIX F:

KAPPA SCORE CALCULATION

Kappa Score Calculation

The formula for Kappa is :

$$K = \frac{\text{observed agreement - chance agreement}}{\text{1 - chance agreement}}$$

Calculation of Kappa for Medial Patellar Glide Test

Chance agreement = (27/50) (18/50) = 0.19

Observed Agreement = 31/50 = 0.62

$$k = \frac{.62 - 0.19}{1.0 - 0.19}$$

$$k = 0.53$$

Calculation of Kappa for Lateral Patellar Glide Test

Chance agreement = (2/50) (0/50) = 0.00

Observed Agreement = 48/50 = 0.96

$$k = \frac{.96 - 0.00}{1.0 - 0.00}$$

$$k = 0.96$$

APPENDIX G:

RAW DATA

Raw Data for Examiner One

Subject Number	*Group	**MPGT	**LPGT	***MCD	***LCD
1	1	2	1	22.10	20.64
2	1	1	1	26.47	16.27
3	1	2	1	17.44	20.21
4	1	1	1	16.97	24.33
5	1	1	1	26.31	12.18
6	1	2	1	23.81	21.18
7	1	2	1	29.86	20.72
8	1	2	1	15.62	20.85
9	1	1	1	16.64	18.85
10	1	2	1	15.64	17.95
11	1	1	1	12.18	18.94
12	1	1	1	29.98	20.40
13	1	1	1	30.37	21.32
14	1	2	1	18.10	17.28
15	1	2	1	16.00	07.27
16	1	2	1	18.09	24.54
17	1	1	1	28.90	21.94
18	1	2	1	15.99	16.68
19	1	2	1	28.12	25.32
20	1	1	1	19.65	26.28
21	1	1	1	24.71	11.67

Subject Number	Group	MPGT	LPGT	MCD	LCD
22	1	1	1	31.37	16.77
23	1	2	1	16.42	16.87
24	1	1	1	24.80	13.83
25	1	1	1	26.19	23.03
26	2	2	1	18.45	27.58
27	2	2	1	19.10	03.16
28	2	2	1	20.24	16.23
29	2	2	1	22.59	25.27
30	2	1	1	29.17	08.75
31	2	1	1	24.85	15.52
32	2	1	1	09.80	19.51
33	2	2	1	12.78	15.63
34	2	1	1	26.44	17.57
35	2	1	1	34.77	22.53
36	2	2	1	27.63	18.43
37	2	1	1	17.24	14.91
38	2	1	1	38.60	11.04
39	2	2	1	26.40	25.66
40	2	2	1	27.56	24.49
41	2	1	1	23.21	17.24
42	2	2	1	21.88	21.31
43	2	2	1	23.09	07.89
44	2	2	1	27.08	16.10

Subject Number	Group	MPGT	LPGT	MCD	LCD
45	2	2	1	10.95	11.04
46	2	2	1	42.10	29.75
47	2	1	1	32.61	12.39
48	2	2	1	22.13	19.37
49	2	1	1	35.87	24.14
50	2	2	1	16.09	17.71

* Group: 1 = Normal knees; 2 = PFP knees

** MPGT & LPGT: 1 = Negative Score; 2 = Positive Score;

***(in mm)

ABBREVIATIONS USED IN TABLE: MPGT- Medial Patellar Glide Test; LPGT- Lateral Patellar Glide Test; MCD- Medial Patellar Caliper Displacement Value; LCD- Lateral Patellar Caliper Displacement Value

Raw Data for Examiner Two

Subject Number	*Group	**MPGT	**LPGT	***MCD	***LCD
1	1	2	1	21.07	27.60
2	1	1	1	47.59	19.65
3	1	1	1	31.35	22.94
4	1	2	1	17.85	28.94
5	1	2	1	28.43	23.65
6	1	2	1	35.33	24.68
7	1	1	1	36.04	23.88
8	1	2	1	28.67	15.80
9	1	1	1	25.15	32.65
10	1	1	2	27.55	20.00
11	1	1	1	25.62	21.20
12	1	1	1	34.68	23.40
13	1	1	1	18.44	30.41
14	1	1	1	18.40	16.40
15	1	1	1	27.76	20.89
16	1	1	1	19.31	25.70
17	1	2	1	21.43	29.36
18	1	1	1	22.32	29.23
19	1	1	1	27.20	26.50
20	1	1	1	15.88	19.64
21	1	1	1	18.67	18.27

Subject Number	Group	MPGT	LPGT	MCD	LCD
22	1	1	1	31.25	19.88
23	1	1	1	20.32	18.54
24	1	1	1	22.94	21.59
25	1	1	1	28.33	25.43
26	2	2	1	22.49	28.68
27	2	2	1	17.25	18.15
28	2	1	1	24.80	27.73
29	2	2	2	37.46	28.71
30	2	1	1	34.42	18.35
31	2	1	1	30.68	31.43
32	2	1	1	21.85	22.34
33	2	2	1	30.00	26.46
34	2	1	1	30.11	17.99
35	2	1	1	34.74	25.86
36	2	2	1	33.89	22.85
37	2	1	1	17.23	22.51
38	2	1	1	18.85	18.82
39	2	1	1	32.55	31.94
40	2	2	1	25.06	27.51
41	2	1	1	29.33	20.77
42	2	2	1	25.98	24.98
43	2	2	1	22.75	16.90
44	2	2	1	26.26	19.32

Subject Number	Group	MPGT	LPGT	MCD	LCD
45	2	1	1	17.83	19.43
46	2	1	1	35.21	24.23
47	2	2	1	29.95	16.53
48	2	1	1	20.62	27.35
49	2	2	1	34.22	24.27
50	2	2	1	23.51	19.68

* Group: 1 = Normal knees; 2 = PFP knees

** MPGT & LPGT: 1 = Negative Score; 2 = Positive Score;

***(in mm)

ABBREVIATIONS USED IN TABLE: MPGT- Medial Patellar Glide Test; LPGT- Lateral Patellar Glide Test; MCD- Medial Patellar Caliper Displacement Value; LCD- Lateral Patellar Caliper Displacement Value